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MINERALS YEARBOOK, 1984

Volume I. Metals and Minerals, prepared by the staff of the Bureau of Mines. 1985. 75 ch. 1034 pp. This volume of the Minerals Yearbook, covering metals and minerals, contains 72 commodity or commodity group chapters with data on approximately 90 minerals that were obtained as a result of the mineral information gathering activities of the Bureau of Mines. In addition, the volume contains a chapter on mining and quarrying trends, a chapter discussing the statistical surveying methods used by the Bureau of Mines, and a statistical summary. GPO Stock No. 024–004–02155–1. $29.

SPECIAL PUBLICATION

SP 1–85. Availability of Land for Mineral Exploration and Development in Southeastern Alaska, 1984, by William S. Roberts. 1985. 34 pp. 20 figs. The Bureau of Mines has initiated a program to determine the availability of land for mineral exploration and development in Alaska. Researchers involved in this program are comparing land availability, based on ownership and government policies and regulations, to the distribution of known mineral deposits and terranes. This report on southeastern Alaska presents the findings of the first of six regional studies that will cover the State. The study consisted largely of data compilation and analysis using various mapping techniques. Summary land availability data are presented on copies of U.S. Geological Survey quadrangles at a scale of 1:500,000. Five categories of land availability were identified: open to mineral exploration and development (approximately 9.4 million acres, or 38% of the 24.8-million-acre study area), open but with possible use restrictions (4.2 million acres, or 17%), selected (0.5 million acres, or 2%), patented (0.74 million acres, or 3%), and formally closed to mineral exploration and development (10 million acres, or 40%). Of the 1,187 known mineral deposits in the study area, approximately 38% are on land in the open category. Mineral terranes comprise approximately 6.7 million acres, or 27% of southeastern Alaska. Approximately 34% of these terranes are on open land. GPO Stock No. 024–004–02158–6. $5.25.

INFORMATION CIRCULAR

IC 9054. Technological Alternatives for the Conservation of Strategic and Critical Minerals—Cobalt, Chromium, Manganese, and Platinum-Group Metals: A Review, by Russell J. Foster. 1985. 53 pp. 1 fig. This Bureau of Mines review focuses on the extent to which technologically and economically feasible programs in substitution, improved processing practices, including recycling, and design can achieve conservation of cobalt, chromium, manganese, and platinum-group metals, and thus reduce U.S. vulnerability to interruptions of supply. In addition, supply-side options—domestic and foreign resources, ocean minerals, and stockpiles—are identified. The report consolidates four major studies on these strategic and critical minerals sponsored entirely or partially by the Bureau in the last few years. These studies have been updated with further information from the recent literature. GPO Stock No. 024–004–02156–0. $2.25.

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REPORTS OF INVESTIGATIONS

RI 8991. Solubilities of Chloride Salts of Alkali and Alkaline-Earth Metals When Sparged With Hydrogen Chloride, by E. G. Noble, D. E. Shanks, and D. J. Bauer. 1985. 17 pp. 13 figs. The effects of hydrogen chloride (HCl) concentration and temperature on the solubility and hydration state of the alkali chlorides LiCl, NaCl, and KCl and the alkaline-earth chlorides, $MgCl_2$, and $CaCl_2$ were investigated by the Bureau of Mines. Saturated aqueous solutions of the chlorides were sparged with HCl gas at temperatures of 20°, 40°, and 60° C. Increased HCl concentration caused decreased salt solubility because of the common ion effect. Aqueous solubilities for the chlorides of Ca, Li, Mg, K, and Na ranged from 42.6, 45.2, 35.2, 25.5, and 26.1 pct, respectively, at 20° C to 56.9, 49.4, 37.6, 31.0, and 27.0 pct, respectively, at 60° C. In solutions sparged to HCl saturation, solubilities for these chlorides ranged from 22.4, 26.5, 3.0, 1.3, and 0.05 pct, respectively, at 20° C to 53.2, 48.8, 28.3, 2.6, and 0.8 pct, respectively, at 60° C. The solubilities of LiCl and $CaCl_2$ in HCl solution were high because HCl solubility is low in these solutions. The chloride salts of Ca, Li, and Mg formed hydrates, which depended on temperature and HCl concentration. Monohydrates for LiCl, tetrahydrates and hexahydrates for $MgCl_2$, and dihydrates, tetrahydrates, and hexahydrates for $CaCl_2$ were obtained.

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RI 8994. Thermodynamic Properties of $CoS_{0.89}$, $CoS_{1.33}$, and CoS_2, by J. M. Stuve, R. P. Beyer, and R. R. Brown. 1985. 11 pp. 1 fig. In this Bureau of Mines investigation, the low-temperature heat capacities of polycrystalline phases corresponding to the sulfide compounds $CoS_{0.89}$, $CoS_{1.33}$, and CoS_2 were measured by adiabatic calorimetry within the nominal temperature range 5 to 300 K. The derived absolute entropies S°_{298} were 10.36 ± 0.02, 12.96 ± 0.03, and 16.31 ± 0.03 cal·mol^{-1}·K^{-1}, respectively, assuming third-law behavior. In addition, the standard enthalpy of formation ΔHf°_{298} of $CoS_{0.89}$ was determined by bromine solution calorimetry. The derived value of ΔHf°_{298} was -50.63 ± 2.1 kcal·mol^{-1}, based on the ΔHf°_{298} of CoO. This result is considerably more negative than previously published formation values based on high-temperature gas equilibrium studies.

RI 8995. Recovery of Metal Values From Copper Converter Flue Dust, by F. J. Palumbo, R. L. Marsh, and R. C. Gabler, Jr. 1985. 10 pp. 5 figs. Effective recycling or disposal of flue dusts is a continuing problem for copper, brass, and bronze smelters. Over 300,000 short tons (st) of dust is generated annually by U.S. secondary copper, brass, and bronze smelters. The Bureau of Mines has developed an alkaline leach method for recovering metal values from copper converter flue dust containing zinc, tin, lead, and copper. The dust was leached with a hot solution of ammonium chloride and ammonium hydroxide to solubilize ZnO. All of the tin (as SnO_2) and the metallic copper, lead, and zinc, as well as possible insoluble compounds of each, report to the residue. Dissolved copper and lead salts are removed from the leachate by cementation with granular zinc. Zinc oxide is precipitated by diluting the leachate with water. The tin-rich (9.8 pct) residue has a ready market. The cement product is recyclable to the smelting operation. The ZnO is at least 97 pct pure and has potential marketability.

RI 8996. The Effects of a Retreating Longwall on a Three-Entry Gate Road System, by Richard A. Allwes, Jeffrey M. Listak, Gregory J. Chekan, and Daniel R. Babich. 1985. 19 pp. 18 figs. The Bureau of Mines conducted an in-mine case study on two consecutive three-entry gate road systems designed in accordance with the stiff-yield pillar design concept. This Bureau study was conducted in order to further develop technology that will improve the health and safety aspects of longwall mining. Support loading and strata activity were monitored to determine the effects of retreat longwall mining on the gate road ground control system. Analyses of pillar stress and roof bolt loading histories revealed that headgate roof support elements experienced cumulative loading throughout the life of the longwall panel. Tailgate pillar loadings had significantly different histories from the loading histories of the headgate pillars. Stress relief occurred in the tailgate pillars following the passage of the longwall face. Moreover, the stiff-yield pillar design, with the abutment pillar placed adjacent to the working panel when part of the headgate system, provided effective ground control in that no major roof falls or roof problems were experienced in the headgate or tailgate systems during longwall mining.

RI 8997. Utilization of Simulated Coal Gases for Reducing Iron Oxide Pellets, by Larry A. Haas, John C. Nigro, and Robert K. Zahl. 1985. 14 pp. 12 figs. The Bureau of Mines is investigating the use of complex gas mixtures, such as would be produced by coal gasification, for reducing iron oxide pellets. A semiempirical model was developed to predict a priori the reduction rate of an iron oxide pellet in a laboratory tube furnace with simulated coal gases at a total pressure of 1 atm. The model uses partial pressures of H_2, CO, CO_2, CH_4 (methane), water vapor, and a temperature-dependent term to predict the rate of reaction. The reduction rate (weight loss per unit of time) was determined with a thermogravimetric apparatus in the temperature range of 800° to 1,100° C. The ranking of the reductants, in order of decreasing reducing potential, is H_2, CO, and CH_4 at temperatures between 800° and 1,000° C; however, CH_4 became a better reductant than CO at 1,100° C. Water vapor did not decrease the reduction rate as much as did CO_2. Carbon deposition was observed at temperatures below 1,000° C with gas mixtures with high CO and low H_2 concentrations. With low-Btu gas at 900° C, over 90 pct of the iron oxide was reduced to iron in less than 3 h. This compares with a reduction time of 1.5 h with medium-Btu gas and 1 h with reformed natural gases.

RI 8998. Fiber Dimensions of Crocidolites From Western Australia, Bolivia, and the Cape and Transvaal Provinces of South Africa, by Kim B. Shedd. 1985. 33 pp. 5 figs. The Bureau of Mines measured fiber dimensions on crocidolites (riebeckite-asbestos and magnesioriebeckite-asbestos) from the world's four crocidolite mining regions. The objective of the study was to determine whether there are measurable morphological differences between crocidolite fibers that correlate with the high reported incidence of mesothelioma in miners and mill employees in the Cape Province of South Africa and Western Australia, as compared with little or no reported incidence of this cancer in the Transvaal Province of South Africa or Bolivia. Fiber dimensions measured with the scanning transmission electron microscope showed that crocidolites from Western Australia and the Cape Province have more thin fibers than crocidolites from Bolivia and the Transvaal Province.

RI 8999. Hydrochloric Acid-Oxygen Leaching and Metal Recovery From a Copper-Nickel Bulk Sulfide Concentrate, by G. A. Smyres, K. P. V. Lei, and T. G. Carnahan. 1985. 17 pp. 10 figs. The Bureau of Mines investigated a HCl-O_2 leaching procedure to recover Cu, Ni, and Co from a low-grade bulk sulfide flotation concentrate prepared from the Duluth gabbro complex. Since the Duluth gabbro complex is the largest known and unexploited Ni resource in the United States, the development of options for extracting the metal values from the flotation concentrate of this domestic resource is necessary. Conditions were determined for producing a pregnant solution low in Fe to facilitate recovery of the metal values. Leaching experiments were conducted at 15 pct solids, 100° to 120° C, 0.2 to 0.3 g HCl per gram concentrate in a 50-gal reactor pressurized to 50 psig with O_2. Base metal extractions from the concentrate were, in percent, 90 to 92 Cu, 99 Ni, 97 to 99 Co, and 0.1 Fe. Precious metals extractions were erratic and unpredictable; at best their extractions were, in percent, 55 Au, 90 Ag, 40 Pt, and 45 Pd. The reaction time at 120° C was 0.5 h. The use of compressed air instead of O_2 as the oxidant was also investigated. Solvent extraction using LIX 622 was used to remove Cu from the pregnant solution. Cementation on Cu was tested for precious metals recovery, while sulfide precipitation was used to produce a Ni-Co product. A conceptual flowsheet for treating the Duluth gabbro concentrate is proposed.

RI 9000. Recent Developments in Spray Cooling of Deep Mines, by Edward D. Thimons, John F. McCoy, and John R. Marks. 1986. 10 pp. 7 figs. This report describes in detail four water spray coolers designed for cooling deep underground mines and discusses the performance of three of them in deep-mine field tests. The four spray coolers were designed and built as part of a Bureau of Mines program to investigate direct-contact (warm air to cool water) spray cooling systems. A single-stage cooling unit was tested in a New Mexico uranium mine, and a two-stage cooler and a three-stage cooler were tested in a South Dakota gold mine. To date, all three coolers have performed well under in-mine conditions and have required only minimal maintenance. Tests on a fourth cooler, a three-stage unit, are under way, but have not been completed.

RI 9001. Calamity Hollow Mine Fire Project. (In Five Parts.) 5. Excavation and Evaluation of the Fire Zone, by K. E. Soroka, R. F. Chaiken, L. E. Dalverny, and E. F. Divers. 1986. 25 pp. 26 figs. The Bureau of Mines has demonstrated a new technological approach that utilizes controlled in situ combustion to bring fires in abandoned coal mines and waste banks under control. This new technology involves the accelerated combustion of "waste" coals in situ under controlled ventilation conditions, which allows for total management of the combustion products, including utilization of the heat produced. This

concept could significantly lower the costs for reducing the environmental and public safety hazards associated with waste coal fires and lead to the conversion of a coal waste to a coal resource. The Burnout Control technique was demonstrated at the site of an abandoned coal mine fire in Allegheny County, PA. Following a 4-month continuous operation of Burnout Control, a novel water injection-fume exhaustion technique was utilized to "rapidly" cool the underground heated zones before the 1½-acre fire site was excavated and backfilled. Observations and interpretations made during excavation relative to fire propagation and quench efficiency are described. Pillar and entry layout, burn regions along entries, roof, and pillars, and degrees of coking of pillars were observed. Borehole temperatures greater than 200° C (392° F) correlated with observed burned and/or coked regions. Water injection-fume exhaustion lowered strata temperature to an average of 160° C (320° F), resulting in minimal gas outbursts and only two local instances of flaming combustion during excavation. The excavation analysis supports the effectiveness of both Burnout Control and water injection-fume exhaustion techniques for control of fires in abandoned coal mines.

RI 9002. Producing Chlorination-Grade Feedstock From Domestic Ilmenite—Laboratory and Pilot Plant Studies, by G. W. Elger, J. B. Wright, J. E. Tress, H. E. Bell, and R. R. Jordan. 1986. 24 pp. 10 figs. The Bureau of Mines investigated the conversion, at both laboratory and pilot plant scale, of a low-grade ilmenite to chlorination-grade feedstock that could substitute for imported rutile used to produce titanium tetrachloride. The concentrate was derived from the Tahawus, NY, lode deposit of ilmenite-magnetite in rock that contains anorthosite and gabbro. Charges of the ilmenite concentrate, containing 46.6 wt pct TiO_2 blended with soda ash, were carbothermically reduced in an electric arc furnace, which separated most of the iron and left a high-titanium slag. However, the slag contained Ca, Mg, and Mn constituents that rendered the material unsuitable for continuous chlorination by causing plugging problems. After being ground and pelletized, the slag was reacted with SO_2 and air at 700° to 900° C, which selectively converted the harmful impurities to soluble compounds that were removed in a subsequent water or dilute HCl leach. In laboratory tests, the combined levels of harmful impurities were decreased from 5 to as low as 0.5 wt pct in leached slags. In pilot plant tests, leached slags sulfated at a rate of 10 lb/h averaged 85.5 wt pct TiO_2 with pertinent impurity levels averaging 1.86 wt pct. The leached slag was successfully chlorinated in a laboratory fluidized-bed reactor at 950° C to extract titanium as $TiCl_4$.

INFORMATION CIRCULARS

IC 9055. Corrosion of Roof Bolt Steels in Missouri Lead and Iron Mine Waters, by M. M. Tilman, A. F. Jolly III, and L. A. Neumeier. 1985. 9 pp. 6 figs. As part of ongoing research to improve mine safety, the Bureau of Mines conducted research on the corrosion of friction rock stabilizer steels in five Missouri lead and iron mine waters. Electrochemical corrosion tests, including evaluation of pitting tendency, were performed on two types of high-strength, low-alloy (HSLA) steels and galvanized steel in four Missouri lead mine waters and one Missouri iron mine water. The tests were conducted at in-mine water temperatures in both air-saturated and deaerated waters. Static, weight-loss corrosion tests were also conducted on HSLA steel specimens in the five Missouri mine waters for a 2,900-h duration at average in-mine water temperatures and air-dissolved oxygen contents of 6 to 7 ppm. Corrosion rates determined by the weight-loss tests were roughly comparable with rates determined electrochemically in deaerated waters containing 0.3 to 0.5 ppm dissolved oxygen content. Passivation of specimen (nongalvanized) surfaces in air-saturated waters resulted in very low electrochemically determined corrosion rates. Pitting tendency was generally higher for both HSLA steels in air-saturated waters than in deaerated waters. Galvanized steel generally exhibited higher tendency to pitting in the deaerated waters than in the aerated mine waters.

IC 9056. Quartz Dust Sources During Overburden Drilling at Surface Coal Mines, by S. D. Maksimovic and S. J. Page. 1985. 7 pp. 2 figs. The Bureau of Mines identified and evaluated major sources of quartz dust during overburden drilling at a surface coal mine. The relative contribution of each source to the total dust hazard was estimated, using personal gravimetric and instantaneous dust-sampling devices. No attempt was made to determine actual dust generation rates. The major sources of dust at the drill rig during dry drilling operations were the collector dump, drill shroud leakage, and drill stem seal leakage. These sources contributed 90 pct of the respirable dust and 89 pct of the respirable quartz dust generated during drilling. The collector dump cycle (21.6 pct of total drilling time) accounted for 38 pct of the respirable dust and 41 pct of the respirable quartz dust, with peak dust concentrations reaching 68 mg/m³. Shroud and drill stem leakage contributed 28 and 24 pct of the respirable dust and 32 and 16 pct of the respirable quartz dust, respectively. A dragline and second drill rig contributed the remaining 10 pct of dust and 11 pct of quartz dust. Gravimetric dust samples collected inside the drill cab and outside, near the cab door, averaged 1.65 and 1.43 mg/m³, respectively, with 6 pct respirable quartz.

IC 9057. Evaluation of Sensitive Ground Fault Interrupters for Coal Mines, by Michael R. Yenchek and Melvin N. Ackerman. 1985. 15 pp. 14 figs. Contacts with energized conductors are a major cause of electrocutions in underground coal mines. Sensitive ground fault interrupters (GFI's) installed on in-mine three-phase ac utilization circuits would probably prevent the majority of these deaths. A sensitive GFI is a protective device that detects and interrupts small deadly ground currents in the milliampere range before those currents can cause ventricular fibrillation in humans. Commercially available three-phase sensitive GFI's have not been specifically designed for application in coal mines. The Bureau of Mines therefore tested three commercial GFI models to determine their worthiness for mine power systems. GFI design and construction, transient immunity, reliability, and time-current characteristics were evaluated in laboratory tests. No commercial device was found suitable for mine use without design modifications. The tests results will serve as a basis for the development of a mineworthy sensitive GFI in ongoing Bureau research.

IC 9058. Anchorage Capacities in Thick Coal Roofs, by Stephen C. Tadolini. 1986. 13 pp. 14 figs. The anchorage capacity of four types of bolting systems was investigated in two mines with thick coal roofs. In conjunction with the in-mine tests, a simple axisymmetric finite element computer program was developed. Both the field and computer results indicated that thick coal roofs can be effectively supported entirely by the coal member.

IC 9059. Precious Metals Recovery From Low-Grade Resources. Proceedings: Bureau of Mines Open Industry Briefing Session at the National Western Mining Conference, Denver, CO, February 12, 1986, compiled by Staff, Bureau of Mines. 1986. 56 pp. 32 figs. This information circular describes research the Bureau of Mines has conducted to improve technology for recovering precious metals from low-grade resources. Many of the reported findings are recent, and some of the work described is ongoing. Topics discussed include cyanidation of carbonaceous gold ores to enhance gold recovery, a new method for precipitating mercury during cyanide leaching of gold ores, a staged heap leaching process to generate suitable solutions for direct electrowinning of gold, and use of anion-exchange resins to recover gold from cyanide solutions, and precious metals recovery from electronic scrap.

SPECIAL PUBLICATION

SP 2–85. Bureau of Mines Research 1985. A Summary of Significant Results in Mineral Technology and Economics, compiled and edited by Jerald R. Pederson. 1985. 124 pp. 61 figs. This publication highlights significant studies in the areas of mining research, minerals and materials research, minerals information, mineral data analysis, and helium operations that were conducted during the past fiscal year at Bureau of Mines facilities and offices. A listing of principal officials, a location map of field facilities, and a selected bibliography of publications and patents issued on Bureau developments during the past 3 years are provided.

BULLETIN

B 681. Dewatering of Mineral Waste Using the Flocculant Polyethylene Oxide, by B. J. Scheiner, Annie G. Smelley, and D. A. Stanley. 1985. 18 pp. 19 figs. This bulletin summarizes the results of Bureau of Mines investigations of a technique for dewatering clay waste that consists of flocculation with polyethylene oxide (PEO) followed by screening of the resulting flocs. Results of laboratory tests and small- and large-scale field tests are described. The PEO dewatering technique has been applied to clay wastes from phosphate, coal, bentonite, and potash operations and to tailings from uranium, talc, and mica mining operations. Fundamental studies to determine the mechanism of PEO interaction with clay particles are also described. This report is based upon work done under an agreement between the University of Alabama and the Bureau of Mines.

MINERAL COMMODITY SUMMARIES 1986

MCS. Mineral Commodities Summaries 1986, by Staff, Bureau of Mines. 1986. 187 pp. 2 figs. This report is the earliest Government publication to furnish estimates covering 1985 nonfuel mineral industry data. Most of the estimates are based on 9 months data. These data sheets contain information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for 87 individual minerals and metals. World resource data appearing in the statements have been provided by the U.S. Geological Survey.

PREPRINTS FROM MINERALS YEARBOOK, 1984

These preprints are chapters from Minerals Yearbook, 1984. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

Chromium, by John F. Papp. 17 pp.
The Mineral Industry of Albania, by Walter G. Steblez. 6 pp.
The Mineral Industry of Australia, by Travis Q. Lyday. 18 pp.
The Mineral Industry of Austria, by George A. Rabchevsky. 14 pp.
The Mineral Industry of Bolivia, by Pablo Velasco. 8 pp.
The Mineral Industry of Bulgaria, by Tatiana Karpinsky. 9 pp.
The Mineral Industry of Colombia, by Orlando Martino. 14 pp.
The Mineral Industry of Hungary, by Walter G. Steblez. 12 pp.
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The Mineral Industry of Norway, by Richard H. Singleton. 12 pp.
The Mineral Industry of Other Areas of South America, by Pablo Velasco and H. Robert Ensminger. 11 pp.
The Mineral Industry of Other Central African Countries, by Thomas O. Glover. 4 pp.
The Mineral Industry of Other South Pacific Islands, by Travis Q. Lyday. 11 pp.
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The Mineral Industry of United Arab Emirates, by Kevin Connor. 9 pp.
The Mineral Industry of Zaire, by George A. Morgan. 8 pp.
The Mineral Industry of Zambia, by Thomas O. Glover. 5 pp.
Zinc, by James H. Jolly. 29 pp.

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Mica (Natural) in 1985 (Annual Preliminary). 5 pp.
The Mineral Industry of Alabama in 1985 (Annual Preliminary). 2 pp.
The Mineral Industry of Alaska in 1985 (Annual Preliminary). 2 pp.
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MSHA	**Mine Safety and Health Administration, Arlington, VA.**
NMH&SA	**National Mine Health and Safety Academy, Beckley, WV.**
OSM	**Office of Surface Mining Library, DOI, Washington, DC.**
PRC/B	**Pittsburgh Research Center (Bruceton), USBM, Pittsburgh, PA.**
RERC	**Reno Research Center, USBM, Reno, NV.**
RORC	**Rolla Research Center, USBM, Rolla, MO.**
SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 102–85. Satellite Monitoring for a Coal Waste Embankment, by F. J. Prokoski, J. T. Byrne, Jr., and D. J. Bryant. Sept. 1984. 45 pp. 29 figs. The COALSTAR Project, which operated from November 1981 to December 1982, was a research and development project aimed at providing a reliable and inexpensive means of monitoring various waste site conditions via the Geostationary Operational Environmental Satellite (GOES) system. The GOES system provides data transfer from unattended isolated sites where neither power nor telephone lines exist. The reliability and resolution of the data received while using the satellite link were excellent; however, the site instrumentation gave considerable trouble. The disastrous failure of a large coal waste embankment in 1972 led the Bureau of Mines to undertake a comprehensive program to reduce the likelihood of recurrence. Part of this program involved the installation of instruments to monitor the stability of a specially selected embankment near Montcoal, WV. Initially, the instruments were monitored by normal telephone lines and used normal commercial power from the local utility. The project described here was initiated to replace this monitoring system with an unmanned, solar-powered data collection system that transmitted data via satellite to a central computer facility. The satellite data network is the National Earth Satellite Service of the National Oceanic and Atmospheric Administration. Research was done under contract H0212017 by Energy Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Copies of this report will not be available for purchase.

OFR 103–85. The Safe Handling of Materials in Bins, by M. D. Marshall. Nov. 1984. 59 pp. 23 figs. This handbook is for the engineer or person responsible for the storage and removal of material from bins and silos in the minerals industry. The objective of the handbook is to prevent bin-related accidents by eliminating problems that require workers to enter bins. It provides basic information on handling materials so that knowledgeable decisions can be made on bin design and accessories to minimize flow stoppages. Materials are classified in terms of their flowability, and bin design and accessories are suggested for each classification. A method for classifying a material is also given, and the various types of material flow aids are reviewed. Safety around bins is the basic theme of the handbook. Federal regulations are reviewed, and additional suggestions are presented to prevent bin accidents. New equipment for releasing material hangups is reviewed. Research was done under contract H0318008 by MSA Research Corp. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–137122; paper copy price code A04. $11.95.

OFR 112–85. Generalization of Medical and Health Compliance Research to Coal Mine Safety, by H. P. Cole, P. K. Berger, T. F. Garrity, C. D. Auvenshine, A. B. Szwilski, M. Hernandez, D. K. Blythe, and W. E. Lacefield. Feb. 1985. 206 pp. 1 fig. Methods for increasing compliance to medical and health regimens were reviewed along with similar research in industrial and mine safety. Principles abstracted from both areas suggest that compliance with health and safety practices is improved when (1) workers are cooperatively involved with management in setting safety goals and planning for their achievement, (2) the program has the support of workers, supervisors, and management, (3) specific tasks responsible for injuries are targeted, (4) company organizational policy, educational, and behavioral programs work together toward the same goals, (5) workers and supervisors are frequently informed about their degree of correct task performance, and (6) programs are monitored by the frequency of correct performance of targeted tasks (the means to lowered accident rates) rather than by lowered accident and injury rates themselves (the goals for safety programs.) Safety programs that incorporate these principles increase persons' adherence to specified health and safety practices and subsequently decrease injury rates. Research was done under contract P0333468 by the Institute for Mining and Minerals Research University of Kentucky. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–138989; paper copy price code A10. $22.95.

OFR 114–85. Development of a Roof Competence Tester, by J. B. Czirr. June 1985. 43 pp. 26 figs. A 4-year program was completed to develop a technique for measuring roof competence in underground coal mines. The preferred technique employs a tracer gas that is injected into a roof borehole drilled near the working face. The tracer gas performs the dual purpose of determining the pressure loss rate from the borehole and of marking the diffusion pattern of the escaping gas. The primary detection technique relies upon observation of the rate of pressure drop in a hole drilled in the roof strata under test. If this measurement indicates a significant probability of roof collapse, the gas diffusion pattern is outlined with the Leakgun tracer-gas detector. These two techniques provide a comprehensive method for predicting the relative probability of roof collapse in operating coal mines. Research was done under contract H0100088 by Minority Enterprise Service Associates Corp. Available for reference at ALRC, AVRC, DRC, LIB, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–135415; paper copy price code A04. $11.95.

OFR 118–85. Development of Self-Contained Self-Rescuer and Enhanced Electrical Hazard Training Materials, by Michael J. Klishis. May 1985. 86 pp. 45 figs. It was the goal of this project to develop training materials specific to two areas of the mining industry: (1) safe use and care of the self-contained self-rescuers, and (2) awareness and avoidance of electrical hazards. This report describes the development of instructor's training modules for self-contained self-rescuers (OCENCO EBA 6.5, CSE AU 9A1, and PASS 700 E); a textbook, slide tapes, and accident case study scenarios for mine electricity; and a computer-based instructional package on mine electricity and electrical hazards. The report concludes that additional efforts are needed in mine training, and four recommendations are made: (1) tailor existing materials to fit specific minesites, (2) develop and evaluate computer-based instructional material, (3) develop parallel training materials for metal and nonmetal mines, and (4) develop additional training materials for preparation plants and surface areas of underground mines. Research was done under contract J0328045 at West Virginia University. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–138914; paper copy price code A05. $11.95.

OFR 119–85. Multiplex Distribution System for Multichannel Pager Communications, by George C. Bowser and William M. Pulford. Dec. 1983. 42 pp. 7 figs. This report covers the development and prototype installation of the multiplex distribution system, which gives private communications capability to simple pager phones at minimum cost. This was accomplished by adding an applique to conventional pager-type telephones to allow them to communicate and interact with a multiplex distribution unit that serves as a miniature private branch exchange. Through this mechanism, the pager phones are able to receive and generate private calls without the expense of a complete multiplex telephone unit at every location. A special commercial telephone interface unit was also developed that allows outsiders to call directly to any pager in the mine and allows mine personnel to call any 1 of 10 preset outside telephone numbers. Research was done under contract H0318010 by Catalyst Research Corp. and Microcom Design, Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–137130; paper copy price code A03. $9.95.

OFR 122–85. Abstracts of Publications and Reports From Coal Mining Technology Research, by Richard S. Fowkes and Cynthia A. Mytrysak. Aug. 1984. 202 pp. This report contains abstracts describing articles, papers, and reports dealing with the contract research results of the Coal Mining Technology Research Program. The report is divided into four major areas: (1) general, (2) underground mining, (3) surface mining, and (4) mine systems. The underground mining section is subdivided into mine planning, mine development, production systems, and logistics. The surface mining section is subdivided into mine planning, production systems, logistics, and reclamation. Within each category, projects are listed chronologically from the earliest to the latest publication. Research was done at the Bureau of Mines Pittsburgh Research Center. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–139003; paper copy price code A10. $22.95.

OFR 123–85. Instrumentation for Remotely Detecting the Placement of Injected Backfill Material, by M. J. Waller, B. G. Stegman, and P. J. Huck. July 1982. 130 pp. 17 figs. Methods of blind backfilling to prevent surface subsidence over abandoned mines have been demonstrated in both flooded and dry workings in recent years. These systems, developed from methods to combat mine fires, involve the injection of slurries containing crushed mine refuse, fly ash, or other material available in large quantities nearby, which are not desired on the surface. A major drawback of all current backfilling methods is the difficulty of monitoring the location and behavior of the injected material underground. The expense of drilling many boreholes to permit physical confirmation of slurry distribution essentially reduces the amount of surface that can be protected, and the drilling itself has negative impacts on surface activities and installations. The objective of this program has been to develop conceptual systems for blind backfill monitoring that will require fewer boreholes and give better definition than is currently possible. Proof-of-concept tests on two recommended systems were conducted in the field. Research was done under contract J0295061 by Earthtech Research Corp. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–139011; paper copy price code A07. $16.95.

OFR 124–85. Cost Benefit Analysis of Low-Coal Cabs and Canopies, by P. D. Lindahl and K. L. Whitehead. Nov. 1983. 144 pp. 5 figs. A cost benefit analysis was conducted by comparing the industry cost to install protective structures on low-coal face equipment with the benefits paid for injuries and/or fatalities considered preventable by the use of these structures. The industry costs were based on estimates by original equipment manufacturers and rebuild shops for installing protective structures on new and rebuilt face equipment. The accident benefits were based on evaluations performed by the Bureau of Mines Accident Cost Indicator Model. Industry-wide population data were developed on low-coal face equipment and injuries and/or fatalities preventable with protective structures. The results of the analysis are to be used as a tool by the Bureau of Mines in determining the feasibility of continuing development of cab and canopy technology for low-coal equipment. Research was done under contract J0199005 by Bituminous Coal Research, Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–138930; paper copy price code A07. $16.95.

OFR 128–85. Development of Prototype Quiet Hard Rock Stoper Drill—Volume I, by Piyush K. Dutta and William N. Patterson. Feb. 1985. 62 pp. 27 figs. This report describes the design, development, and manufacture of a prototype quiet hard-rock stoper drill and results of its field tests. It is shown that the stoper drill noise level can be reduced from 118 dBA to below 100 dBA by using this design. The design concept of this drill is based on a valveless independent rotation system and use of an integral muffler and pivot mount. The drill was manufactured in a standard commercial drill manufacturing setup and organization. The design and production technology proved that commercially viable quiet drills can be made available for mine use. Research was done under contract H0113034 by Creare Products Inc. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–139722; paper copy price code A04. $11.95.

OFR 134–85. Report of Second Meeting on the Definitions and Scope of Nonfuel Mineral Production Statistics in America, by the Department of Scientific and Technological Affairs, Organization of American States. Sept. 1985. 130 pp. The purpose of the meeting described in this paper is to improve understanding of statistics on mineral production and processing collected and/or published by the participating countries—Argentina, Bolivia, Brazil, Canada, Colombia, Mexico, Peru, United States, and Venezuela. This report, a summary of the deliberations of the 2d Meeting on the Definitions and Scope of Nonfuel Mineral Production Statistics in America, held September 16–21, 1984, in Buenos Aires, Argentina, consists of two major sections. The first provides data for each participating country for 12 commodities, iron ore, manganese, copper, lead, zinc, gold, silver, molybdenum, tin, tungsten, fluorspar, and phosphate rock, as provided at the conference. The second part presents the data on each commodity into one or more summary tables, each on as nearly a standard basis as is possible. Explanatory text describes differences in definitions as necessary for understanding of the tabular material. Research was done under contract J0145048 by the Organization of American States. Available for reference at AD/MI and LIB. Order ONLY from NTIS: PB 86–144318; paper copy price code A07. $16.95.

OFR 135–85. Strategic and Critical Materials Program Annual Report 1985, by R. E. Chaney. May 1985. 125 pp. 53 figs. This report summarizes the research on the Strategic and Critical Materials Program tasks conducted at the Idaho National Engineering Laboratory between May 1984 and April 1985. The work is divided into two areas: production technologies and conservation and/or substitution technologies. Production technologies, tasks directed at developing advanced extraction technologies, include biologically assisted minerals processing, metal-gas reactions and thermal plasmas, and dehydration of aluminum chloride hexahydrate. Conservation and/or substitution technologies, tasks directed toward establishing the technical processing base that will permit the use of advanced materials, include joining of rapidly solidified alloys (RSA), joining of silicon nitride-based ceramics, nondestructive evaluation of ceramic and RSA joints and materials, and substitute catalytic materials for platinum. Research was done under contract J0134035 at the Department of Energy Idaho National Engineering Laboratory. Available for reference at AD/MMR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–144540; paper copy price code A07. $16.95.

OFR 1–86. Distribution, Analysis, and Recovery of Gold From Kantishna Placers, Alaska, by Steven A. Fechner and Robert B. Hoekzema. 1986. 54 pp. 11 figs. In 1983, the U.S. Bureau of Mines, using contractors and conducting independent studies, evaluated the mineral resources of the Kantishna Hills area of Denali National Park and Preserve, south-central Alaska. Geological and engineering studies addressed types and abundance of mineralization, mineral development potential and acquisition costs of mineral claims. The Bureau of Mines collected reconnaissance and site specific bulk placer samples to evaluate the mineral development potential of 27 drainages and analyze the size distribution of gravel and gold on 5 streams in the Kantishna Hills study area. Sizing studies conducted on five streams suggest that over 99% of the gold ranges from minus 6

to plus 70 mesh with the biggest percentage being plus 40 mesh in size. Recommended placer recovery plants on these streams should be designed to recover plus 70-mesh gold and classify gravels to minus 1 mesh in size prior to processing through a recovery device. Ten streams were rated as having high mineral development potential; 5 of these streams lack current mining activity. Available for reference at AD/MDA, AFOC/J, IFOC, LIB, AND WFOC. Copies of this report are not available for purchase.

OFR 4–86. Explosively Induced Fracture and Fragmentation in Copper Porphyry, by Navid Mojtabai. June 1984. 54 pp. 16 figs. Experiments were conducted to obtain an understanding of the nature and processes of rock fragmentation near a borehole in rock blasting. Ten controlled impact experiments on quartz monzonite were performed using the inclined-plane wave generator to induce a uniaxial compressive wave. Particle size distribution and microcrack density in quartz grains were determined as a function of stress levels (between 1.6 GPa (16 kb) and 7.3 GPa (73 kb)) and pulse durations (between 1.1 μs and 6.9 μs). Both shock pressure and pulse duration were shown to have a strong effect on both particle size and microcrack density. Although the effect of pressure is well recognized, the effect of pulse duration indicates that the ultimate fragmentation increases with the time of application of a plane wave pulse. At high pulse durations, both the degree of fragmentation and microcracking are more sensitive to change in pressure than at low pulse durations. The degree of fragmentation increases rapidly as the microcrack density is increased. Research was done under grant G1125149–3501 at the New Mexico Institute of Mining and Technology. Available for reference at AD/MR, LIB, and PRC/B. Copies of this report are not available for purchase.

OFR 5–86. Shock Wave Propagation and Attenuation in Quartz Monzonite Porphyry, by Kenrick H. Lee. Sept. 1985. 112 pp. 19 figs. The propagation and attenuation of shock waves in quartz monzonite were investigated to improve the understanding of the controlling parameters that influence shock wave characteristics and rock material behavior under shock loading. Four instrumented impact experiments were performed on quartz monzonite using a 4-in helium gas gun to induce a uniaxial compressive wave. Input shock pressures for the impact events ranged from 22 to 71 kb, and pulse durations ranged from 0.3 to 2.3 μs. A change in slope of the shock velocity versus particle velocity curve, observed at about 25 kb, is attributed to the onset of pore collapse. Shock data for quartz monzonite and other rocks reveal that the shock velocity versus particle velocity curve appears to shift downward with increasing porosity. The pressure versus volume Hugoniot curve is concave downward, which may also have resulted from the onset of pore collapse. The pulse attenuation rate is shown to decrease with pulse duration. Research was done under grant G1125149–3501 at the New Mexico Institute of Mining and Technology. Available for reference at AD/MR, LIB, and PRC/B. Copies of this report will not be available for purchase.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 1–86. Mineral Resources of the Antelope Creek Study Area, Phillips County, Montana, by J. Douglas Causey. 1986. 19 pp. 13 figs. Western Field Operations Center, Spokane, WA.

MLA 2–86. Mineral Resources of a Part of the Dos Cabezas Mountains Wilderness Study Area (AZ–040–065), Cochise County, Arizona, by Jeanne E. Zelten. 1986. 31 pp. 7 figs. Intermountain Field Operations Center, Denver, CO.

MLA 3–86. Mineral Resources of the Cow Creek Wilderness Study Area, Blaine and Phillips Counties, Montana, by Michael S. Miller. 1986. 28 pp. 4 figs. Western Field Operations Center, Spokane, WA.

MLA 6–86. Mineral Investigation of the Worley Ridge RARE II Area (08224), Rabun County, Georgia, by John T. Neubert. 1986. 17 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

MLA 7–86. Mineral Investigation of the Board Camp and Raven Cliff RARE II Study Areas, Lumpkin, Union, and White Counties, Georgia, by Robert H. Wood II and Robert A. Welsh, Jr. 1986. 32 pp. 3 figs. Intermoutain Field Operations Center, Denver, CO.

IV. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 36–85. Methane Drainage With Cross-Measure Boreholes on a Retreat Longwall Face, by Pramod C. Thakur, Stephen D. Lauer, and Joseph Cervik. Pres. at Soc. Min. Eng. AIME Fall Meeting and Exhibit, Salt Lake City, UT, Oct. 19–21, 1983. Soc. Min. Eng. AIME preprint 83–398, 13 pp.; also in Min. Eng., v. 37, No. 12, Dec. 1985, pp. 1375–1380. Methane drainage by cross-measure boreholes on retreat longwall faces can be a viable alternative to the vertical gob degas boreholes under favorable circumstances. This study, the first application of this technique in the Pittsburgh coal seam, was performed in a working mine in northern West Virginia. Fourteen small-diameter, inclined boreholes were drilled over a retreat longwall panel from gate roads, to intersect the overlying coal seams. All boreholes were manifolded to a pipeline and the gob gas was extracted by an exhaust fan on the surface. The methane capture ratio was poor at 7% to 18% at various stages of the longwall panel. A vertical gob degas borehole captured an additional 20% gas. Poor results were caused by premature failures of the cross-measure boreholes leading to air leakage. For better performance, the boreholes should be drilled from a point 30 to 45 m from the longwall pillar over the largest chain pillar, the standpipe should be grouted for at least 6 m, and the entry containing boreholes and the pipeline must be supported to ensure access for maintenance and the optimization of methane capture. Coursing the ventilation air around the longwall such that it forces methane-migration toward cross-measure boreholes can further improve methane capture. The optimum vertical inclination is 45° to 10°.

OP 88–85. Preparation of Tungsten Carbide by Gas Sparging Tungstate Melts, by J. M. Gomes, A. E. Raddatz, and T. G. Carnahan. Paper in Tungsten: 1985. MPR Publ. Serv., Ltd., Shrewsbury, England, 1985, pp. 96–109; also in J. Met., v. 37, No. 12, Dec. 1985, pp. 29–32. The Bureau of Mines has devised a new technique for the preparation of tungsten monocarbide (WC) directly from ore concentrates by a two step process. Wolframite or scheelite concentrates of mixtures of the two concentrates are decomposed in a NaCl-Na_2SiO_3 melt at 1,050° C. The melt forms two immiscible liquids. The upper halide-tungstate (NaCl-Na_2WO_4) phase contains 99% of the WO_3. The lower silicate phase contains 90% to 96% of the iron, manganese, and calcium oxides. After separating the two phases by decantation, the halide-tungstate phase is methane sparged to yield granular tungsten carbide. The WC is recovered from the reactor by decanting excess salt, cooling, water leaching, and scraping. The paper discusses results of research to establish operating variables, carbide harvesting procedures, selection of materials of construction, estimated cost of production, and physical properties of the WC product.

OP 1–86. Precalculation of Subsidences Over Longwall Panels in the Northern Appalachian Coal Field, by V. Adamek and P. W. Jeran. Soc. Min. Eng. AIME preprint 85–404, 1985, 17 pp. The specific lithological conditions over the Pittsburgh coalbed, highly resistive limestone and sandstone units with relatively shallow overburden, prevent the use of any predictive method as developed for European conditions. This paper describes the development of a subsidence precalculation methodology suitable to the mining-geological conditions in the Northern Appalachian Coalfield. It has been found that due to lithological conditions over the Pittsburgh coalbed, the subsidence coefficient varies within the area of the subsidence trough. This is different from the European conditions where the subsidence coefficient is considered to be a constant. The effects of lithology, in the form of a variable subsidence coefficient, have been separated for each test site by introducing a correlation between hypothetically homogeneous overburden and existing lithological conditions, while providing for different mining conditions. Field data from 11 Bureau longwall panel studies were used in the regression analysis. For each panel, the characteristics of the variability of the subsidence coefficient along individual profile lines were defined. Regression analysis of the subsidence coefficients from all test sites on the location relative to the edge of the panel has yielded a third degree polynomial equation with a coefficient of correlation of 0.9999. All sensitivity tests have shown good results.

OP 2–86. Treating Superalloy Scrap With Zinc To Increase Its Leaching Rate, by G. B. Atkinson and D. P. Desmond. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 337–348. The Bureau of Mines investigated technology for increasing the leaching rate of bulk superalloy scrap by treating the scrap with zinc. This technology would facilitate recycling contaminated superalloys and recovering critical metals such as Ni, Co, and Cr. Superalloys investigated were IN–738, a cast-nickel-base superalloy, and Mar–M–509, a cast-cobalt-base superalloy. Charges containing 80 pct Zn and 20 pct superalloy were heated to 900° C for 4 h in an argon atmosphere. The molten zinc dissolved the superalloy scrap, and the zinc was removed by vacuum distillation at 850° C for 4 h. The product was friable, contained less than 0.2 pct Zn, and more than 99.9 pct for the zinc was recovered. Leaching 5 g of product with excess 6*N* HCl at 95° C for 5 h dissolved 95 pct of the superalloy component metals.

OP 3–86. Sorting Techniques for Mixed Metal Scrap, by R. D. Brown, Jr., W. D. Riley, and D. M. Soboroff. Conserv. & Recycling, v. 9, No. 1, 1986, pp. 73–86. The U.S. Bureau of Mines is conducting research on methods for sorting and identifying mixed metal scrap so that this resource can be better utilized. A mechanical method for separating wrought and cast aluminum scrap and instrumental methods for identifying mixed aluminum scrap and mixed high-value scrap are reviewed. New research on spark testing and field experience in high-value scrap sorting are discussed.

OP 4–86. Coal and Gas Outbursts: Prediction and Prevention, by Alan A. Campoli, Michael Trevits, and Gregory M. Molinda. Coal Min., v. 22, No. 12, Dec. 1985, pp. 42–44, 47. An outburst in a coal mine environment is the rapid ejection of coal and gas from the face. Outbursts are caused by a combination of high coalbed gas pressure and structural stress, created by the load placed upon mine workings by overburden. A review of the outburst problem in general is followed by a presentation of prediction and prevention techniques employed worldwide to mitigate outbursts.

OP 5–86. A Case Study of Ground Control Problems Related to Multiple Seam Mining in the Pittsburgh and Sewickley Coalbeds, by Gregory J. Chekan, Rudy J. Matetic, and James A. Galek. Soc. Min. Eng. AIME preprint 85–325, 1985, 10 pp. The Bureau of Mines, U.S. Department of the Interior, is currently investigating strata interactions associated with the mining of multiple coalbeds. Strata interactions due to subsidence are a result of undermining. This study involves underground investigations at a mine where room and pillar panels are actively being developed through an area of the Sewickley Coalbed that was subsided by undermining of the Pittsburgh Coalbed. Research to date indicates that undermining had little effect on upper mine pillar stability but had a more severe effect on the development and maintenance of entries. Roof-to-floor measurements recorded over four times more convergence in entries developed over gob as compared with entries developed over support pillars in the lower mine. Consequently, this has led to major roof falls in the active panels, resulting in considerable production delays and supplemental roof support costs.

OP 6–86. Concentrating a Complex Cobalt and Nickel Sulfide From Missouri Lead Ores by Continuous Froth Flotation, by W. L. Cornell, D. C. Holtgrefe, and F. H. Sharp. Paper in Complex Sulfides—Processing of Ores, Concentrates, and By-Products, ed. by A. D. Zunkel, R. S. Boorman, A. E. Morris, and R. J. Wesely. Metall. Soc. AIME, 1985, pp. 181–193. The Missouri lead ores are the only domestic sources of cobalt presently being mined and processed for other materials. They therefore represent the best short-term solution for meeting up to 20 pct of U.S. strategic and critical cobalt needs from domestic sources. At present, the cobalt is lost as an impurity in the Cu, Pb, and Zn concentrates and in the mill tailings. This paper presents research to enumerate the problems encountered in recovering cobalt from the copper concentrate on a continuous basis under actual mill conditions; to present alternative solutions to these problems; and finally, to describe what is presently the best available technology for cobalt recovery within the imposed constraints. Flotation was chosen as the method for recovery because of easy adaptation by the mills. In the best cases, when feeds in excess of 0.8 wt pct Co were encountered, cobalt recoveries in excess of 80 wt pct at grades as high as 8.2 wt pct were achieved. On average, however, cobalt recoveries of 60 wt pct at grades of 2.0 wt pct on feeds containing less than 0.4 wt pct would be typical.

OP 7–86. Recovery of Cobalt and Other Metal Values From Missouri Lead Ore Concentrator Tailings, by W. L. Cornell, D. C. Holtgrefe, and F. H. Sharp. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 675–682. Missouri lead ores are unique because they represent the only domestic cobalt resource that is presently being mined and processed. Lead, zinc, and copper concentrates are produced from the ore, and since cobalt is detrimental in these products, every effort is made to reject cobalt to the mill tailings. The tailings can contain as much as 45 pct of the cobalt originally present in the lead ore. Researchers at the Bureau of Mines Rolla Research Center used froth flotation to recover up to 65 wt pct of the cobalt and from 60 to 90 wt pct of the other valuable metals such as Ag, Cu, Pb, and Zn from the mill tailings. An augmented primary amine collector was used. Desliming of the pulp prior to flotation was not necessary. Improvement ratios range from 7 to 17 depending on the metal.

OP 8–86. Polarization and Corrosion of Electrogalvanized Steel—Evaluation of Zinc Coatings Obtained From Waste-Derived Zinc Electrolytes, by M. Dattilo. J. Electrochem. Soc., v. 132, No. 11, Nov. 1985, pp. 2557–2561. The corrosion of electrogalvanized 1070 steel wire has been investigated in molar quiescent ammonium chloride and ammonium sulfate under near-neutral conditions. Zinc coatings obtained from waste-derived electrolytes were evaluated versus coatings from relatively pure zinc electrolytes. The waste source of zinc was brass smelter flue dust. Corrosion rates were measured by Tafel line extrapolation and the polarization resistance technique. Values of the Tafel slopes and the corrosion currents were also compared with those for pure zinc (99.999%). Corrosion rates were found to be affected by the medium employed, pH, and bimetal diameter reduction (drawing). Drawn electrogalvanized

steel displays higher values of the Tafel slopes than do the as-plated samples. The Tafel slopes are different from those obtained on pure zinc. This is assumed to be due to inhomogeneous surface features obtained from additive adsorption (during plating) and residual lubricants used in the drawing process as well as surface structure. The corrosion rates of electrogalvanized samples plated in the waste-derived zinc electrolytes were similar to the corrosion rates of samples plated in relatively pure zinc electrolytes. Therefore, wastes are a potential source of zinc for electrogalvanizing.

OP 9–86. Recycling Zinc From Flue Dust for Electrogalvanizing, by M. Dattilo, E. R. Cole, Jr., T. J. O'Keefe, R. A. Kosher, T. J. O'Keefe, Jr., and F. Chen. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 159–172. An objective of Bureau of Mines recycling research is to devise technology that enables the recovery of metals and minerals from wastes. In this report, researchers at the Bureau of Mines, U.S. Department of the Interior, and at the University of Missouri-Rolla investigated the use of the flue dusts containing zinc as a source of zinc for electrogalvanizing. After extraction of zinc with sulfuric acid, the resultant solution was partially purified and used to electrogalvanize 1070 alloy steel wire, a common electrogalvanized product. Bench-scale tests were successful, and a 400-lb coil of 1090 alloy steel wire was electrogalvanized in an industrial pilot plant. Corrosion performance and drawability of the coil plated in waste electrolyte compared favorably with that of a coil plated in industrial electrolyte.

OP 10–86. Electrogalvanizing Using Zinc Recovered From Nonferrous Smelter Dusts, by M. Dattilo, E. R. Cole, Jr., and T. J. O'Keefe. Conserv. & Recycling, v. 9, No. 1, 1986, pp. 55–66. An objective of the U.S. Bureau of Mines recycling research is to devise technology that enables the recovery of metals, minerals, and other values from waste products and thus promote the wise and efficient use of the resources of the United States. In line with this objective, Bureau researchers are investigating the use of waste products containing zinc as a source of zinc for electrogalvanizing. Industrial wastes used in this work were lead smelter flue dust, wastewater treatment sludge, copper smelter flue dust, and brass smelter flue dust. After zinc extraction with sulfuric acid, the resultant solutions were partially purified and used to electrogalvanize 0.234-cm (0.092-in.) diameter 1070 alloy steel wire, a common electrogalvanized product. The corrosion resistance of the electrogalvanized wire from waste electrolyte was compared with electrogalvanized wire from relatively pure electrolyte prepared in the laboratory and with electrogalvanized wire from an industrial electrogalvanizing plant. Corrosion rate measurements indicated that electrogalvanized wire obtained from waste electrolyte prepared from brass smelter flue dusts compared favorably with industrial electrogalvanized wire and electrogalvanized wire from the relatively pure electrolyte. The brass smelter flue dusts were chosen for more detailed studies. Impurities in the waste electrolyte caused some problems. Copper was undesirable because it passivated the soluble zinc anode. Other impurities such as cobalt and nickel were more tolerable but also slowly coated the anode. Owing to the ease of removal of copper by cementation, it posed no processing problem for electrogalvanizing. Successful completion of bench-scale work with brass smelter flue dusts led to large-scale trials at an industrial electrogalvanizing plant.

OP 11–86. A Novel Technique for the Recovery of Coarse North Carolina Phosphate, by B. E. Davis, T. O. Llewellyn, and G. V. Sullivan. Soc. Min. Eng. AIME preprint 85–331, 1985, 6 pp. A technique was devised by the Bureau of Mines to recover coarse (plus 1.2 mm) North Carolina phosphate now discarded as waste. Concentration utilizes the difference in particle sphericity between the relatively flat calcite and the rounded phosphate pebbles. Sizing, treatment in a continuous hydraulic classification system, and grinding upgraded a 17.0-pct-P_2O_5 reject to 24.5 pct P_2O_5, with a phosphate recovery of 63 pct.

OP 12–86. Sensor Location Strategy for Minewide Environmental Monitoring, by Thomas J. Fisher and A. F. Cohen. Paper in Proceedings of the 21st International Conference of Safety in Mines Research Institutes, Sydney, Australia, Oct. 21–25, 1985, pp. 393–398. The decision to incorporate a mine monitoring system into a coal mine represents a commitment by management and engineering personnel to improve mine operations though innovative technology. The choice of monitoring transducers requires considerable planning and forethought so that the maximum benefits of whole mine monitoring can be realized. The intended use of the monitored data will often dictate specific locations for transducers, although in many cases technical constraints, imposed by transducers or measurand characteristics, will limit the choice of location. This paper presents some of the factors and considerations that should be examined prior to transducer installations. Some decision making procedures to help the system designer select appropriate locations are proposed. The paper includes a description of in-mine experimental programs being used to learn more about physical factors that influence transducer location and to further evaluate the procedures presented here.

OP 13–86. Distribution of Cr, As, Se, Ag, Cd, Ba, Hg and Pb in Pacific Ocean Ferromanganese Nodules, by Jane Z. Frazer, Benjamin W. Haynes, and Robert R. Sims, Jr. Wastes in the Ocean—Volume 5, Deep-Sea Waste Disposal, ed. by Dana R. Kester, Wayne V. Burt, Judith M. Capuzzo, P. Kilho Park, Bostwick H. Ketchum, and Iver W. Duedall. Wiley, 1985, pp. 260–270. Fifty-five bulk ferromanganese nodule samples from the Pacific Ocean were analyzed for total content of Cr, As, Se, Ag, Cd, Ba, and Hg. Concentrations of Pb and other metals had been determined previously for the same samples. Cadmium and barium are correlated positively with Mn, Ni, Cu, and Zn, and negatively with Fe, Co, As, and Pb. Cadmium seems to occur primarily in the 10 Å manganate phase of the nodules, whereas Ba occurs at least partly in the form of barite. Chromium probably occurs in the sediments incorporated within the nodules and is correlated positively with As and Si and negatively with Mn. Arsenic and mercury are correlated with Fe, and As is also correlated positively with Co and Pb and negatively with Mn, Ni, Cu, and Zn. Arsenic and mercury are associated presumably with the iron oxide phases. Like Co, they are especially concentrated in regions characterized by seamounts and may be of volcanic origin. Silver and selenium showed no clear trends. Concentrations of the toxic elements in nodules from the region between the Clarion and Clipperton Fracture Zones, where deep ocean mining is most likely to occur, can be compared with the maximum levels allowed by the U.S. Environmental Protection Agency (EPA) if a solid is not to be considered a toxic waste. Concentrations of Cr, Ag, and Hg are so low that they are of no environmental concern. Levels of As, Cd, and Ba are borderline; they could present a toxicity problem if they occurred in the rejects entirely in soluble form. Lead and selenium are observed in nodules in concentrations considerably higher than allowed by EPA for nonhazardous wastes. Since Se and Pb are the most likely elements to make the rejects toxic, further studies should pay particular attention to these elements.

OP 14–86. Partial Replacement of Chromium in Stainless Steel, by M. L. Glenn, S. J. Bullard, D. E. Larson, and S. C. Rhoads. Paper in New Developments in Stainless Steel Technology, ed. by R. A. Lula. Am. Soc. Met., Dec. 1985, pp. 99–105. The Bureau of Mines, U.S. Department of the Interior, conducted research on the partial replacement of chromium in stainless steel. The alloys examined contain 8 to 9 pct Cr, 11 to 14 pct Ni, and additions of up to 5 pct Mo, 2 pct Cu, and 2 pct V for corrosion-resistant applications, and up to 5 pct Si and 2 pct Al for heat-resistant applications. Molybdenum additions enhanced the corrosion resistance to approach that of type 304 stainless steel (304 SS) in H_3PO_4, HNO_3, citric acid, and acetic

acid. Alloys with Si and Al additions had 800° C oxidation resistance superior to that of type 304 SS. The stress rupture resistance of the best Si-Al alloys was comparable to that of type 304 SS. The alloys had tensile properties typical of austenitic or martensitic stainless steels, depending upon their structures. They exhibited greater tendency to hot crack during welding than did type 304 SS. The research showed that additional levels of Ni, Mn, or C may be needed to stabilize an austenitic structure in these substitutes. The research also showed that additions such as Mo, Si, and Al have potential to substitute for approximately half the Cr in stainless steels for many applications.

OP 15–86. Electrolytic Removal of Tin From Can Scrap, by J. G. Groetsch, Jr., R. C. Gabler, Jr., and D. M. Soboroff. Conserv. & Recycling, v. 9, No. 1, 1986, pp. 15–22. Tin in the magnetic fraction of municipal solid waste (MSW) makes this material difficult to recycle to the steel industry. An electrolytic method using stannous fluoborate-fluoboric acid for removing tin was evaluated on a laboratory scale. Optimum concentrations of tin in the electrolyte and the effects of impurities such as aluminum, copper, iron, and lead on tin removal from the electrolyte were evaluated. Operating parameters were 60 to 65 g/L fluoboric acid and 20 to 30 g/L tin using stainless steel electrodes at a current density of 60 A/ft². Tests were run with clean tin cans and MSW magnetics with good results. The tin content of the MSW magnetics scrap was reduced from 0.18 to 0.017 wt % tin by reshredding, magnetic separation, and air classification, followed by electrolytic removal of the tin.

OP 16–86. The Relationship Between the Thermal Activity of Pyrite and the Rate of Acid Generation, by Richard W. Hammack. Paper in 1985 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation. Univ. KY, 1985, pp. 139–144. The thermal reactivity of pyrite in 33 overburden samples was evaluated by evolved gas analysis (EGA). Eight samples contained carbonaceous material; large exothermic effects resulting from the combustion of this material rendered EGA thermograms from these samples meaningless. EGA techniques and instrumentation capable of evaluating carbonaceous samples have been developed but were not available for this study. Therefore, the results of this study are based on 25 noncarbonaceous overburden samples.

OP 17–86. Characterization of Waste Materials From Manganese Nodule Processing, by Benjamin W. Haynes, David C. Barron, Gary W. Cramer, Robert W. McKibbin, and Stephen L. Law. Paper in Marine Mining: A New Beginning—Conference Proceedings, July 18–21, 1982, Hilo, Hawaii, ed. by Peter B. Humphrey. State of Hawaii Marine Mining Program, 1985, pp. 116–140. In cooperation with several other Federal agencies, the U.S. Department of the Interior, Bureau of Mines, is investigating the composition of manganese nodule processing feed material and the possible reject waste material composition from several types of potential manganese processing options. In this study, both pilot plant and bench-scale-generated rejects are being studied for chemical composition and physical characterisitcs. This paper reports the results and estimates of reject waste material composition from five process types considered for first-generation manganese nodule processing. Particular emphasis is placed on two ammonia-based bench-scale processes.

OP 18–86. Reclamation of Metals From Magnet Alloy Grinding Sludge, by J. L. Holman and L. A. Neumeier. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 327–336. The Bureau of Mines has devised a procedure for treating cobalt-nickel-bearing magnet alloy grinding sludge to remove detrimental contaminants and produce an alloy powder for recycling. Sulfur contamination can result from use of elemental sulfur as fixturing cement for grinding. Carbon contamination results from residual oil and grinding-wheel debris. Since magnet alloys have low tolerances for these elements, they must be removed to low levels to render the metallics recyclable. The patented technique consists of (1) treatment with solvent to remove most of the sulfur and oil contamination, (2) drying, light grinding, sizing, and magnetic separation of a major portion of the grinding media, (3) controlled oxidation roasting to remove residual sulfur and carbon, and (4) hydrogen reduction of metal oxides. The powder product contained about 0.01 pct S, 0.06 pct C, and 30 pct Al_2O_3. When added to an experimental alnico melt, the alumina floated to the slag. Overall, >95 pct of the Co, Ni, and Fe and ~90 pct of the Cu were recovered from the starting sludge sample.

OP 19–86. Permselective Membrane Research for Stainless Steel Pickle Liquors, by G. L. Horter, J. B. Stephenson, and W. M. Dressel. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 467–475. Acid pickling of stainless steel annually generates approximately 30 million gallons of depleted nitric acid-hydrofluoric acid solutions as an undesirable byproduct. Disposal of these acid solutions significantly increases the cost of manufacturing stainless steel. Recent advances in ion-selective membrane technology have opened new avenues to economically regenerate these acid solutions as an alternative to disposal. Experimental work has indicated that an electrodialysis cell utilizing ion-selective membranes has potential for separating dissolved metals from depleted pickling acid solutions, allowing the acids to be regenerated for return to the pickling process.

OP 20–86. Fundamentals of Continuous Dielectric Separation of Minerals, by C. E. Jordan and G. V. Sullivan. Soc. Min. Eng. AIME preprint 85–383, 1985, 24 pp. The fundamental properties of the Bureau of Mines patented dielectric separator were studied to provide insight regarding its design and operating characteristics. Force equations for mineral particles were derived and evaluated experimentally. High dielectric mineral recovery was proportional to the calculated effective dielectric force volume that surrounded each drum electrode wire. Electrode spacing was the most sensitive design parameter, requiring less than 0.4-cm electrode spacing for a good separation. Operating characteristics and ore characteristics were investigated. With a dielectric constant difference as small as 2, good separations were made on a laboratory scale at energy consumption below 12 kw-h/mt.

OP 21–86. Treatment of Mine Water To Remove Manganese, by Robert L. P. Kleinmann, George R. Watzlaf, and Terry E. Ackman. Paper in 1985 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation. Univ. KY, 1985, pp. 211–217. The Bureau studied two novel approaches to the manganese problem. One was an inexpensive pipeline treatment system device known as the in-line aeration and neutralization system (ILS), which was developed by the Bureau to aerate and neutralize mine water. At three mines with influent Mn concentrations of 10 to 68 mg/L, use of the ILS reduced Mn concentrations to less than 2 mg/L at pH values of only 6.8 to 7.3. Another novel approach to mine water treatment is the construction of wetlands on mined sites. Results from ongoing tests indicate that this biological treatment can be engineered to optimize either iron or manganese removal. Moderate Mn concentrations (14 to 30 mg/L) have been reduced to 2 to 6 mg/L in constructed wetlands at four minesites in western Pennsylvania.

OP 22–86. Spoil Water Quality Variations at Two Regraded Surface Mines in Pennsylvania, by Kenneth J. Ladwig and Peter Campion. Paper in 1985 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation. Univ. KY, 1985, pp. 121–130. Field studies at two reclaimed surface mines in Pennsylvania were used to describe the hydrology and water quality within acid-producing spoil backfill. The study examined the relationsip between recharge

source and water quality and empirically described the geochemical evolution of the spoil water.

OP 23–86. Assessment and Reclamation of an Abandoned Acid-Producing Strip Mine in Northern Clarion County, Pennsylvania, by Peter J. Lusardi and Patricia M. Erickson. Paper in 1985 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation. Univ. KY, 1985, pp. 313–321. The Pennsylvania Department of Environmental Resources and the Bureau of Mines are conducting a reclamation project aimed at controlling acid production at its source by surface application of high-quality limestone. The site of this project is a backfilled strip mine that discharges acidic water at three seepage areas. The site was reclaimed in May and June 1984 using 327 metric tons per hectare of high-quality limestone. The effect of the reclamation on water quality is currently being assessed in the last phase of the project. One year after reclamation, there has been no major improvement in the water quality in the wells and seeps. A sharp decrease in sulfate and acidity levels in two of the seeps occurred in late 1984; however, the improvement did not persist.

OP 24–86. End Uses of Boron Other Than Glass, by Phyllis A. Lyday. Ch. 17 in Borates: Economic Geology and Production, ed. by James M. Barker and Stanley J. Lefond. Soc. Min. Eng. AIME, 1985, pp. 255–264. The growth of the boron industry began when Marco Polo brought borax to Europe from Tibet in the 13th century. The paper is limited to uses other than glass, which account for approximately one-half of domestic consumption and cover a range of exotic uses. Depending on the concentration, boron can be both an explosive or a flameproofer and a fertilizer or a herbicide. Some of these uses require highly purified and concentrated forms of boron while other uses require only the crude ores. These nonglass uses include metallurgical fluxes, boron alloys, thermal neutron absorbers, bleaches, detergents, dyes, adhesives, nylon, and corrosion inhibitors.

OP 25–86. Electrolytic Preparation of Fe-Ni-Cr Alloys Using a Particle-Occlusion and Heat-Treatment Method, by G. R. Smith and J. E. Allison, Jr. J. Met., v. 37, No. 12, Dec. 1985, p. 55. As part of a research effort to conserve strategic and critical metals, the U.S. Department of the Interior, Bureau of Mines, has developed a modified aqueous electrodeposition method for preparing Fe-Ni-Cr alloy coatings and electroforms. This method involves mechanically suspending Cr powder (averaging 2 μm diam) in a ferrous-nickelous sulfate electroplating bath and occluding the Cr particles in the electrodeposited Fe-Ni alloy matrix. Subsequent heat treatment of the resulting composite coating forms the ternary alloy. The occlusion process is affected by the quantity of Cr powder suspended as well as by the microstructure and composition of the electrodeposited matrix. The largest quantity of chromium is occluded when the electrodeposited matrix exhibits a dual-phase γ(Ni,Fe)-α(Fe,Ni) microstructure. Coatings with up to 20 wt pct Cr have been deposited from an electrolyte containing 20 vol pct suspended Cr powder. Heat treatment at 1,100° C for 8 h effectively homogenizes the composite coating. Alloys containing 55Fe-29Ni-16Cr produced by this method corroded at a rate of only 0.7 mm/yr during 240 h of exposure to boiling 65 pct HNO_3. Applicability of this method to the preparation of electroforms has also been demonstrated.

OP 26–86. Case Studies of Long-Term Methane Extraction From Coal, by Michael A. Trevits and Gerald L. Finfinger. Soc. Min. Eng. AIME preprint 85–333, 1985, 7 pp. In the course of Bureau of Mines research, various methods have been developed to remove gas in advance of, during, and subsequent to mining. Such methods include the drilling of horizontal or cross-measure boreholes from a mine opening, and vertical boreholes stimulated for drainage in advance of mining or for gob gas drainage. Techniques and equipment now exist that allow for the drilling of a borehole at any angle to the vertical (and even along an arc). Stimulation treatments have also been developed that provide for increased gas production capability. This paper briefly describes the long-term production history of five select gas drainage installations.

OP 27–86. Chlorination-Grade Feedstock From Domestic Ilmenite, by J. B. Wright, G. W. Elger, J. E. Tress, and H. E. Bell. Miner. and Metall. Process., Nov. 1985., pp. 198–202. This paper describes laboratory techniques and subsequent results of U.S. Bureau of Mines research to produce chlorination-grade feedstock from an abundant, low-grade, domestic, rock ilmenite ore. The research is part of the Bureau effort to devise technology that may help decrease U.S. dependence on imported raw materials. A rock ilmenite containing about 46 wt pct TiO_2 was smelted in an electric arc furnace with coke, woodchips, and Na_2CO_3 to separate most of the iron as pig iron and to form a low-iron, titanium-enriched slag. The slag was ground, pelletized, oxidized, and then sulfated with mixtures of SO_2 and air in a continuous 4.5- to 9.1 kg/h (10- to 20-lb/h) apparatus at 1,023 to 1,223 K (1,380° to 1,740° F). The sulfated slag, containing 60 pct to 65 pct TiO_2, was reground and leached in water at ambient temperature to decrease the combined levels of the troublesome calcium, magnesium, and manganese impurities from 7.0 to 1.7 wt pct. The final product was upgraded to about 84 wt pct TiO_2. This material is potentially suitable for chlorination in a fluidized-bed reactor. The most favorable results were achieved with leached slag sulfated at a feed rate of 4.5 kg/h (10 lb/h) and at temperatures of 1,073 to 1,123 K (1,470° to 1,560° F).

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REPORTS OF INVESTIGATIONS

RI 9003. Large-Scale Laboratory Drag Cutter Experiments in Hard Rock, by R. J. Morrell, D. A. Larson, and D. E. Swanson. 1986. 18 pp. 8 figs. The Bureau of Mines conducted a series of laboratory experiments to test a cutting technique for hard rock using large-scale drag cutters. Cutting experiments were performed on rocks ranging in compressive strength from 10,000 to 27,000 lb/in^2, using large drag cutters from 3 to 6 in in width. The tests were conducted on a special test apparatus, called a ripper tester, which made a curvilinear cut across the rock sample while measuring the cutting force acting on the drag cutter. The cutting method that evolved from these experiments is called ripper cutting, and its energy efficiency appears superior to all other large-scale mechanical fragmentation techniques. In addition, the method created very little dust, and the wear on the bits was negligible. A fragmentation system based on ripper cutting was then devised, and a large-scale test device was fabricated to allow full-scale laboratory testing of the system. The results of these tests will be published in future Bureau reports.

RI 9004. Evaluation of a Ground Penetrating Radar System for Detecting Subsurface Anomalies, by Ronald H. Church and William E. Webb. 1986. 21 pp. 18 figs. The Bureau of Mines tested a ground penetrating radar (GPR) system in the central Florida phosphate district to determine the feasibility of utilizing GPR technology for subsurface cavity detection. The test area is located in karst topography where sinkhole development is prevalent. State regulations require subsurface drilling of damsites to identify underground anomalies; however, this method is not totally accurate in locating subsurface cavities that could lead to sinkhole development. An electromagnetic method of identifying anomalous subsurface conditions could reduce or eliminate the possibility of dam failure due to sinkhole development. The Bureau devised a GPR system that successfully penetrated over 50 ft of overburden and gave recognizable radar return signals characteristic of a rock-cavity interface. This research at the Tuscaloosa Research Center was carried out under agreements between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama and the Florida Institute of Phosphate Research.

RI 9005. Microwave Drying of Fine Coal, by David P. Lindroth. 1986. 12 pp. 5 figs. The objective of this research by the Bureau of Mines was to determine the technical feasibility and associated pilot data for drying minus ¼-in coal with microwave energy at a frequency of 2.45 GHz. The drying data were obtained experimentally on three coal types: bituminous, subbituminous, and lignite. The experiments were performed with a custom-designed conveyorized microwave oven having a continuous power capability of 12 kW. Drying efficiencies near the theoretical maximum of 1.54 kg of water per kilowatt hour of energy input were achieved for two coals and two sizes; overall drying efficiencies averaged 77 pct.

RI 9006. Performance Characteristics of Large-Capacity Face Ventilation Systems for Oil Shale Mining, by Edward D. Thimons, Carl E. Brechtel, Marv E. Adams, and Joseph F. T. Agapito. 1986. 15 pp. 11 figs. The performance of two large-capacity ventilation systems was compared through tests conducted in a large dead-end heading at a pilot oil shale mine in Colorado. Sulfur hexafluoride (SF_6) tracer gas was used to measure the performance of the two systems: a freestanding jet fan and a reversible fan with rigid duct. The tracer gas was used to simulate the production of mine air pollutants, including blasting pollutants, hot diesel emissions, free methane from surrounding strata, and methane desorbing from muck piles. The test room was 55 ft wide, 30 ft high, and 320 ft long. The performance of the two fans was similar, but the jet fan used less power. The tests showed that either system could provide effective ventilation during oil shale mining.

RI 9007. Investigation of Similarities Between Methane Drainage Potential of Utah's Sunnyside Coalbed and Eastern U.S. Coalbeds, by Gregory M. Molinda, Thomas M. Kohler, and Gerald L. Finfinger. 1986. 10 pp. 7 figs. The Bureau of Mines has completed an investigation of the effectiveness of methane drainage in the Lower Sunnyside Coalbed at Kaiser Steel Corp.'s Sunnyside No. 1 Mine in Utah. Most of the previous attempts to drain methane gas using long horizontal holes were conducted in the Eastern Coal Province. From the high degree of success realized in these efforts and the large body of knowledge gained from associated research, it seemed natural to extend the technology to western coalfields. Previous work had indicated that properties affecting gas drainage were variable in the Sunnyside Coalbed. In an attempt to characterize these properties, four degasification holes were drilled from the outside entries of an advancing section. The holes were drilled to lengths of 780, 1,680, 1,315, and 1,047 ft and produced initial flow rates of 50,000, 180,000, 340,000, and 240,000 ft^3/d, respectively. A total of over 300 million ft^3 of commercial-quality gas has been removed from the Sunnyside Coalbed. The four holes have reduced face emissions by 78 pct.

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IC 9060. Fluorspar Availability—Market Economy Countries and China. A Minerals Availability Appraisal, by Catherine C. Kilgore, Sandra R. Kraemer, and James A. Bekkala. 1985. 57 pp. 22 figs. The Bureau of Mines investigated the availability of fluorspar (CaF_2) from 36 U.S. and 50 foreign mines and deposits in 13 countries. Only 6 U.S. properties are considered to be economic, as 29 domestic deposits were found to have an average total cost of production that was uneconomical at a break-even (0-pct) discounted-cash-flow rate of return (DCFROR). The 50 foreign properties evaluated represent at least 85 pct of demonstrated fluorspar resources located in market economy countries and China. All evaluated foreign operations were found to be economic to marginally economic in January 1984 dollars when compared against published prices for each country. Reserves for 56 properties totaled 97 million metric tons (mt) (recoverable CaF_2) from demonstrated ore resources of 344 million mt that contained 123 million mt CaF_2. The average total cost needed to cover all costs over the life of each operation was determined for all

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recoverable fluorspar products. Comparisons of mining, beneficiation, and transportation costs per metric ton of fluorspar concentrate illustrate advantages between countries. Of the three countries with the greatest fluorspar production, China, with its high-grade, low-cost operations, had the lowest weighted-average total cost of production ($38/mt concentrate). Mexico was next, at $54/mt concentrate, and benefited in U.S. dollar terms from the devaluation of the peso. The Republic of South Africa needed an average of $90/mt of concentrate to cover all costs of production at its large low-grade deposits.

BULLETIN

B 683. Resource Recovery From Municipal Solid Waste, by Martin H. Stanczyk and Roger S. DeCesare. 1985. 31 pp. 34 figs. As part of its mission to investigate and encourage recovery and recycling technologies, the Bureau of Mines studied the feasibility of recovering metal and nonmetallic mineral values from municipal solid waste. This bulletin reviews Bureau research conducted primarily between 1966 and 1979, which covered various aspects of recycling municipal solid waste and included operation of both a municipal incinerator residue and a raw (unburned) refuse continuous-separation pilot plant. The report describes the products recovered from incinerated and raw refuse and research in upgrading, refining, and/or utilizing the various metal and mineral products. The data are based on approximately 100,000 lb of residues and nearly 1 million lb of raw refuse processed in the pilot plants. Products recovered from incinerator residue included 20 to 30 wt pct ferrous metals, 2 to 3 wt pct nonferrous metals, and 30 to 40 wt pct glass; products from raw refuse included 4 to 8 wt pct ferrous metals, less than 1 wt pct nonferrous metals, 4 to 17 wt pct glass, and 63 to 83 wt pct combustibles. Use of the Bureau's technology at commercial plants in the United States and abroad is briefly described.

PREPRINTS FROM MINERALS YEARBOOK, 1984

These preprints are chapters from Minerals Yearbook, 1984. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

The Mineral Industry of Brazil, by H. Robert Ensminger. 15 pp.
The Mineral Industry of Central American Countries, by Doris M. Hyde. 16 pp.
The Mineral Industry of Chile, by Pablo Velasco. 12 pp.
The Mineral Industry of China, by E. Chin. 24 pp.
The Mineral Industry of Denmark and Greenland, by Richard H. Singleton. 13 pp.
The Mineral Industry of the Federal Republic of Germany, by George A. Rabchevsky. 21 pp.
The Mineral Industry of France, by Roman V. Sondermayer. 19 pp.
The Mineral Industry of the German Democratic Republic, by George A. Rabchevsky. 12 pp.
The Mineral Industry of Greece, by Walter Steblez. 13 pp.
The Mineral Industry of India, by Gordon L. Kinney. 22 pp.
The Mineral Industry of Indonesia, by John C. Wu. 15 pp.
The Mineral Industry of Italy, by Roman V. Sondermayer. 14 pp.
The Mineral Industry of Mexico, by Orlando Martino. 21 pp.
The Mineral Industry of North Dakota, by James H. Aase and David W. Brekke. 7 pp. 2 figs.
The Mineral Industry of Other East African Countries, by Kevin Connor. 16 pp.
The Mineral Industry of Other Near East Countries, by Ben A. Kornhauser and Thomas O. Glover. 13 pp.
The Mineral Industry of Other West African Countries, by Ben A. Kornhauser. 8 pp.
The Mineral Industry of the Republic of South Africa, by George A. Morgan. 23 pp.
The Mineral Industry of Saudi Arabia, by John R. Lewis. 11 pp.
The Mineral Industry of Spain, by Roman V. Sondermayer. 7 pp.
The Mineral Industry of Sweden, by Richard H. Singleton. 14 pp.
The Mineral Industry of Thailand, by Gordon L. Kinney. 11 pp.
The Mineral Industry of Venezuela, by Harold R. Newman. 9 pp.

II. Open File Reports—NTIS

An open file report is an unpublished Bureau of Mines report that has been made available as reference material. Any open file report may be inspected during working hours at the locations indicated but may not be removed, except that the Natural Resources Library, U.S. Department of the Interior, Washington, DC 20240, can usually supply copies on interlibrary loan. The Natural Resources Library will also reproduce up to 25 pages without charge and under some circumstances can provide microfiche; contact the Chief, Circulation and Interlibrary Loan, 202–343–5815, for further information on any of these services.

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In the open file listings that follow, the symbols indicate facilities where reports are available for inspection. (See list for key symbols.)

AD/MDA	**Assistant Director—Mineral Data Analysis, USBM, Washington, DC.**
AD/MI	**Assistant Director—Minerals Information, USBM, Washington, DC.**
AD/MMR	**Assistant Director—Minerals and Materials Research, USBM, Washington, DC.**
AD/MR	**Assistant Director—Mining Research, USBM, Washington, DC.**
AFOC/A	**Alaska Field Operations Center, USBM, Anchorage, AK.**
AFOC/F	**Alaska Field Operations Center, USBM, Fairbanks, AK.**
AFOC/J	**Alaska Field Operations Center, USBM, Juneau, AK.**
ALRC	**Albany Research Center, USBM, Albany, OR.**
AVRC	**Avondale Research Center, USBM, Avondale, MD.**
DOI	**U.S. Department of the Interior.**
DRC	**Denver Research Center, USBM, Denver, CO.**
IFOC	**Intermountain Field Operations Center, USBM, Denver, CO.**
LIB	**Natural Resources Library, DOI, Washington, DC.**
MSHA	**Mine Safety and Health Administration, Arlington, VA.**
NMH&SA	**National Mine Health and Safety Academy, Beckley, WV.**
OSM	**Office of Surface Mining Library, DOI, Washington, DC.**
PRC/P	**Pittsburgh Research Center (Bruceton), USBM, Pittsburgh, PA.**
RERC	**Reno Research Center, USBM, Reno, NV.**
RORC	**Rolla Research Center, USBM, Rolla, MO.**

SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 105–85. Mine Particulate Size Characterization, by R. W. Welker, W. Eisenberg, R. A. Semmler, and G. J. Yucuis. Jan. 1982. 207 pp. 6 figs. A technique was developed for sampling and analyzing airborne dusts in diesel-operated underground metal and nonmetal mines. Samples were taken using personal respirable samplers, operated as area samplers, and an 11-stage cascade impactor. Real-time particle size distribution and concentration measurements were made with a quartz crystal microbalance cascade impactor and a portable electrical aerosol analyzer. The materials characterized were minerals (by X-ray diffraction), elements (by X-ray fluorescence), particle size distribution and concentration (gravimetrically), and organic constituents (by high-performance liquid chromatography). The method was used to characterize dusts generated at the chute pulling operations on the main haulage level of an underground tungsten mine. Analysis showed that respirable dust concentration ranged from 0.8 to 2.3 mg/m^3. It consisted of silica (3% to 7%), organic constituents from diesel exhaust (0.11 to 0.31 mg/m^3 equivalent airborne concentration), and mineral dust (39% to 100%). The remainder was diesel exhaust particles. It was concluded that size selective sampling may be used to estimate the ratio of diesel exhaust to nondiesel dusts in the respirable fraction. Research was done under contract J0199086 by IIT Research Institute. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–142163; paper copy price code A10. $22.95.

OFR 109–85. Advancement of Cab and Canopy Design and Use in Coal Mines, by W. W. Aljoe and K. L. Whitehead. Aug. 1981. 306 pp. 83 figs. The use of protective canopies can result in canopy roofing and/or serious restrictions to operator comfort and vision. To document this experience, a field study was conducted of cab and canopy design and application that resulted in a catalog of 164 canopy designs. An analysis of field data showed no simple relationship between working height and canopy-related problems. The relationship also involves (1) machine frame height, (2) mine floor undulations, (3) operator compartment dimensions, and (4) canopy design and location on the machine. Data analysis indicates (1) present technology does not always permit successful application of canopies in working heights below 42 inches and (2) development of satisfactory low-coal canopies is doubtful. The basic conclusion of the study is that future research and development studies should be directed at development of alternative protection systems and remote mining methods. Research was done under contract J0199005 by Bituminous Coal Research, Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–153574; paper copy price code A14. $28.95.

OFR 116–85. Demonstration of a Mine Shaft Fire and Smoke Protection System for Coal Mines, by Ralph B. Stevens. Mar. 1983. 294 pp. 54 figs. The goal of this research was to increase the safety of workers in underground coal mines by developing and in-mine testing a low-cost, available, and flexible fire safety system to reduce the spread of fire and contaminated air in or near mine shafts. The work detailed information on the magnitude of the hazard, industry acceptance of remote data acquisition systems, and alternative fire safety systems to meet four different mine profiles. A complete fire reporting system was designed, installed, and in-mine tested at a Midwest underground coal mine from April 1980 to March 1983. The surface-located master control unit provided analog displays of real-time sensor data and a printer graph-record of the last 24 hours of activity. Fire warning sensors included ionization particle sensors, electrochemical cell carbon monoxide (CO) analyzers, a solid-state CO analyzer, and continuous heat-sensitive wire sensors. Multiplex telemetry of data occurred on existing telephone lines and wireless radios from shafts up to a 5-mile distance. Four fire conditions occurred during in-mine testing that demonstrated the system's effectiveness. Evaluation of converting the system to meet MSHA approval is included. Research was done under contract H0100017 by ESD Corp. Available for reference at AD/MR, DRC, LIB, MSHA, NMH&SA, PRC/B, TCRC, and SRC. Order ONLY from NTIS: PB 86–146933; paper copy price code A13. $22.95.

OFR 120–85. Retrofit Noise Control of Underground Load-Haul-Dump Machines, by Mathew N. Rubin. July 1984. 110 pp. 65 figs. The primary objective of this work was to extend the noise control technology developed under earlier projects to a wider range of load-haul-dump models to evaluate the general applicability of these techniques. Noise control treatments were designed, fabricated, and installed on three load-haul-dump machines (two 2-yd^3 models and one 8-yd^3 model) selected as demonstration machines for this project. The machines were evaluated either in production mines or at the Bureau's Lake Lynn Mine. The results indicate that it is possible to achieve overall noise reductions of between 4 and 8 dB using these techniques. Engine cooling and seal design were determined to be important design issues in such treatments. Research was done under contract H0395041 by Lake Shore, Inc. and Bolt Beranek and Newman, Inc. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–145810; paper copy price code A06. $16.95.

OFR 121–85. Deviation Control for Bored-Raise Pilot Holes, by Nicholas P. Callas. Dec. 1981. 109 pp. 6 figs. This report presents research results obtained in the investigation of deviation control of boreholes in the rotary drilling process. The approach taken in this research is the passive method of placing stabilizers in the bottom-hole assembly to control deviation. Extensive use was made of the drill string mechanics theories of Lubinski and Woods. Analog, digital, and hybrid solutions to a variety of boundary value problems were investigated to determine the best models for bottom-hole assemblies. Field drilling data were analyzed, and the results obtained from various models were compared with the actual drilling results. Various accomplishments of this work have been published in Bureau of Mines Information Circular 8891. Research was done under contract J0285005 by the Department of Mathematics, Colorado School of Mines. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–147196; paper copy price code A06. $16.95.

OFR 125–85. Development of Modular Irrigation Systems for Reclaimed Strip Mined Lands Incorporating Mycorrhiza Inoculations Trials, by A. Uiga, J. A. Kinkead, and W. K. Ostler. Dec. 1984. 150 pp. 29 figs. The U.S. Bureau of Mines funded a project that addressed objectives concerning irrigation of native plants and inoculation of native plants with vesicular-arbuscular mycorrhizal (VAM) fungi. The specific irrigation objectives were (1) to demonstrate the performance capabilities of solid-set irrigation for reclaimed mineland conditions and (2) to demonstrate and evaluate three irrigation concepts under two separate water supply conditions. The VAM inoculations were to assess irrigation benefits in establishing VAM relationships for transplanted native species. Following the seasonal demonstration (May to September 1983) at three separate minesites, conclusions were made that apply to the six-State Western mining industry. The demonstration sites were located in Montana, Wyoming, and New Mexico. Positive conclusions were reached for (1) the use of soil moisture sampling with or without irrigation and (2) the selection of solid-set sprinklers as the irrigation method. The conclusions

about the irrigation concepts and strategy were mixed because of the short-term (one season) nature of the project. No conclusions could be reached for the VAM inoculations because the study time was too short. Research was done under contract H0222004 by Sherman and Kinkead Consulting Engineers, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–154119; paper copy price code A08. $16.95.

OFR 3–86. Environmental and Occupational Health Regulations in the U.S. Lead Industry, by Carl W. Anderson, Paul T. Behum, and Frederick W. Miller. Jan 1986. 76 pp. 3 figs. This report presents a Bureau of Mines study of regulations pursuant to four major environmental and occupational health laws and the compliance problems of primary and secondary lead smelters and lead-acid battery manufacturers. Technical feasibility and difficulties in implementing and administering the following standards are addressed: (1) the Occupational Safety and Health Administration standards for occupational exposure to lead, (2) the Environmental Protection Agency (EPA) national ambient air quality standard for lead, (3) the EPA hazardous waste management regulations pertaining to recycling of lead, and (4) the EPA effluent limitations under the Clean Water Act and amendments. Although alternative technologies for lead production are emerging and engineering controls are available for retrofitting existing facilities, the economic viability and universal adaptability of these measures are uncertain. Additional pilot and demonstration plant tests may be required for new lead smelting and refining processes. Regulatory approaches in dealing with compliance problems on a plant-by-plant basis would be beneficial. Such an approach should consider the technical and economic feasibility of engineering controls on existing processes and take into account the level of development of new processes. Research was done by the U.S. Bureau of Mines Division of Minerals Policy and Analysis. Available for reference at AFOC/J, IFOC, LIB, PRC/B, and WFOC. Order ONLY from NTIS: PB 86–155686; paper copy price code A05. $11.95.

OFR 8–86. Bag Machine Dust Controls and Bag Sealing, by T. L. Muldoon, J. W. Valentine, and M. Burnett. May 1985. 74 pp. 41 figs. The bagging of dry pulverized products using fluidized air packers creates severe respirable dust problems in many surface mining operations. During bag filling, excess air and product blows by the bag valve-nozzle interface. After bag ejection, dust blows out of the bag valve. During bag conveying and handling, dust is released from the bag valve and dirty bag surface. Overexposure of the bagging machine operator and bag handlers is common. This report describes the development and testing of a new dust control system for bagging machines. The system features a new bag clamp design to reduce product blowby during filling. A controlled vacuum system removes excess air from the bag before ejection, eliminating the problems after bag ejection and during conveying and handling. The system has shown significant reductions in dust exposure for both bag machine operators and bag handlers. These reductions are achieved with no significant effect on total mill productivity. Research was done under contract H0318013 by Foster-Miller, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–153558; paper copy price code A04. $11.95.

OFR 16–86. The Solubilization of Byproduct Molybdenum From Low-Grade Copper Materials, by Terry L. Hebble, Larry A. Haas, and George A. Dumont. 1983. 22 pp. 7 figs. The Bureau of Mines is investigating hydrometallurgical procedures for recovering byproducts from low-grade copper materials. This report discusses research involving the leaching of low-grade molybdenum-bearing copper ore. The molybdenum concentration found in sulfuric acid leachate from low-grade copper ores is typically very low (less than 2 ppm). Research was performed to determine conditions required to improve molybdenum solubilization. The variables studied were pH, oxidation-reduction potential, metal ion concentrations, and nature of oxidant type. In both basic and acidic (stirred) reactor tests, over 80 pct of the molybdenum was extracted at ambient temperature and pressure in 24 h (or less) with strong oxidizing reagents such as sodium hypochlorite in a basic medium or in a nitric-hydrochloric acid solution. With weaker oxidants, such as hydrogen peroxide and manganese dioxide, in sulfuric acid solution at pH 1, <2 pct of the molybdenum was extracted. With basic solutions and lean ore (0.03 pct Mo), a large quantity (210 times stoichiometric) of sodium hypochlorite was required to obtain 80 pct extraction in 24 h. The extractions at pH <1 or near 10 were dependent on the oxidizing power of the oxidant rather than the solubility limit of molybdenum. However, at about pH 3, the presence of 0.1 to 0.3 g/L ferric ions precipitated >80 pct of the molybdenum from a prepared solution while other metal ions common to dump leach liquor, such as copper, manganese, magnesium, and aluminum, removed <20 pct of the molybdenum. Therefore, in order to obtain high (80 pct) molybdenum extractions from copper ores, the pH of the leach must be <0.5 or approximately 10, and the initial oxidation-reduction potential of the lixiviant must be >0.8 V for acidic leaching. Research was done by the Bureau of Mines Twin Cities Research Center. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 23–86. Zeolite Determination and Geothermometry Interpretations Associated With Buried Volcanic Rocks in Oil Fields in Northwestern Mississippi, by Daniel A. Sundeen. Feb. 1986. 22 pp. 4 figs. A study was conducted to confirm the presence of zeolites and determine the type of zeolite minerals associated with the subsurface volcanic province in Humphreys, Leflore, and Holmes Counties, northwestern Mississippi. The petrographic microscope and X-ray diffraction with the Gandolphi camera were the primary tools used to identify the minerals. The most abundant zeolite mineral was analcite. Natrolite and chabazite were both suspected as minor mineral components in several locations. Other minerals such as celestite, ankerite, and clay (illite type) were found in the process of looking for zeolites. The abundant presence of analcimite indicates that the temperature regime associated with volcanism is relatively low, probably no higher than 120° to 130° C, which is not enough heat to degrade hydrocarbons to a noncommercial state. Study results indicate that thermal contribution to the trapping system by past volcanic events in the area does not increase the risk of successful oil well drilling. Research was done under grant G1144128 at the University of Southern Mississippi. Available for reference at LIB. Copies of this report will not be available for purchase.

OFR 24–86. The Examination of Landsat, Gravity and Magnetic Anomalies as Indicators of Subsurface Hydrocarbon Accumulation Geophysical Correlations in West-Central Mississippi, by Larry D. Schutts and Gwynne A. Woodward. Sept. 1985. 78 pp. 19 figs. Recent analysis of near-infrared Landsat data has revealed the existence of five circular tonal anomalies in the vicinity of Belzoni in west-central Mississippi. One feature is located just southwest of an area that yielded modest amounts of Smackover Formation oil and gas. Each of the others may represent reservoirs associated with structures in the underlying Sharkey platform. Research was done under grant G1144128 at the University of Mississippi. Available for reference at LIB. Copies of this report are not available for purchase.

OFR 25–86. Tertiary Lignites of Kemper and Northern Lauderdale Counties, Mississippi, by Shair E. T. Rahaim, Jr. Oct. 1985. 109 pp. 21 figs. Samples of lignite from thin, tabular seams ranging from a few centimeters to almost 3 meters in thickness in Kemper and Lauderdale Counties, MS, were studied by proximate, petrographic, mineralogical, and grain size analyses. Proximate analysis of the samples indicates high moisture (30%), ash (63%), and volatile matter (21%), and low fixed carbon (12%) values. Grain size and mineralogical analyses indicate a predominance of sand-size quartz in the lignite. Petrographic analysis indicates that humodetrinite (37%) and gelinite (27%) are the major organic constituent

particles. The inertinite macerals (19%), fusinite and semifusinite, are unusually high in these low-grade coal seams. The cellular macerals, textinite and ulminite, compose only 11%, and corpohuminite and exinite compose 5% of the lignite samples studied. The values from these analyses seem to indicate that the lignite was deposited in a deltaic environment influenced by fluvial and marine processes. The paleo-environment was dominated by herbaceous plants and wood from angiosperms and lacked significant amounts of conifers in the depositional area. Research was done under grant G1144128 at the University of Southern Mississippi. Available for reference at LIB. Copies of this report will not be available for purchase.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 4–86. Mineral Resorces of the Seven Blackfoot Study Area, Garfield County, Montana, by Michael S. Miller. 1986. 13 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 8–86. Mineral Investigation of the Rabun Bald (8–147) and Rand Mountain (8–148) RARE II Study Areas, Rabun County, Georgia, by Clay M. Martin. 1986. 48 pp. 6 figs. Intermountain Field Operations Center, Denver, CO.

MLA 9–86. Mineral Investigation of the Baboquivari Peak Wilderness Study Area (AZ–020–203B), Pima County, Arizona, by John R. McDonnell, Jr. 1986. 10 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MLA 10–86. Mineral Resources of the North Fork Owyhee River Study Area, Owyhee County, Idaho, by Andrew M. Leszcykowski. 1986. 8 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 11–86. Mineral Resources of the Yatahoney Creek Wilderness Study Area, Owyhee County, Idaho, by Andrew M. Leszcykowski. 1986. 9 pp. 2 figs. Western Field Operations Center, Spokane, WA.

III. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 88–85. Preparation of Tungsten Carbide by Gas Sparging Tungsten Melts, by J. M. Gomes, A. E. Raddatz, and T. G. Carnahan. Paper in Tungsten: 1985. MPR Publ. Serv., Ltd., Shrewsbury, England, 1985, pp. 96–109; also in J. Met., v. 37, No. 12, Dec. 1985, pp. 29–32; and in Int. J. Refract. & Hard Met., v. 4, No. 4, Dec. 1985, pp. 177–181. The Bureau of Mines has devised a new technique for the preparation of tungsten monocarbide (WC) directly from ore concentrates by a two-step process. Wolframite or scheelite concentrates or mixtures of the two concentrates are decomposed in a $NaCl\text{-}Na_2SiO_3$ melt at 1,050° C. The melt forms two immiscible liquids. The upper halide-tungstate ($NaCl\text{-}Na_2WO_4$) phase contains 99% of the WO_3. The lower silicate phase contains 90% to 96% of the iron, manganese, and calcium oxides. After separating the two phases by decantation, the halide-tungstate phase is methane sparged to yield granular tungsten carbide. The WC is recovered from the reactor by decanting excess salt, cooling, water leaching, and scraping. The paper discusses results of research to establish operating variables, carbide harvesting procedures, selection of materials of construction, estimated cost of production, and physical properties of the WC product.

OP 28–86. Determination of Gallium in Phosphorus Flue Dust and Other Materials by Graphite Furnace Atomic Absorption Spectrometry, by David C. Barron and Benjamin W. Haynes. Analyst, v. 111, Jan. 1986, pp. 19–21. A simple, rapid method for the determination of gallium in inorganic matrices using Zeeman-corrected graphite furnace atomic absorption spectrometry (GFAAS) is described. The method uses an acid dissolution technique, $Mg(NO_3)_2$ as a matrix modifier, and the method of standard additions. The 294.4-nm wavelength is used to improve the signal-to-noise ratio without loss of sensitivity. Gallium was determined in phosphorus flue dust and also in coal fly ash, copper ore, and steelmaking flue dust. The procedure is used as an alternative to neutron-activation analysis (NAA) and as intermediate in sensitivity between flame atomic absorption spectrometry and NAA. A comparison of GFAAS and NAA results is presented.

OP 29–86. Dissolution Behavior of 304 Stainless Steel in HNO_3/HF Mixtures, by B. S. Covino, Jr., J. V. Scalera, T. J. Driscoll, and J. P. Carter. Metall. Trans. A, v. 17A, Jan. 1986, pp. 137–149. The dissolution behavior of type 304 stainless steel was studied in typical pickling environments in an effort to reduce the unnecessary loss of the critical metals nickel and chromium during the pickling process. Dissolution rates were determined for a 90-minute exposure to HNO_3/HF solutions ranging from 0.8 *M* to 3.5 *M* HNO_3 and 0.5 *M* to 2.6 *M* HF at 30°, 50°, 70°, and 90° C and containing 0 to 0.21 *M* dissolved Fe, Cr, or Ni. Dissolution rates increased as a function of increasing HNO_3 concentration from 0.4 *M* to 1.5 *M* HNO_3, decreased at higher HNO_3 concentrations, and increased with increasing HF concentration. Experiments to determine the effect of temperature on the dissolution reaction gave a lower activation energy for solutions with higher HNO_3 concentrations. The dissolved Fe and Cr decreased the dissolution rate of 304 stainless steel while dissolved Ni had essentially no effect. The Auger electron spectroscopy and X-ray photoelectron spectroscopy studies of films resulting from exposure to several HNO_3/HF solutions indicated that the fluoride did not penetrate the thin nonprotective films but remained on the outer surface of the film. The scanning Auger microscopy studies indicated that the fluoride was uniformly distributed over the surface. Both the dissolution and surface studies are consistent with a dissolution process that is controlled by reactions occurring either in solution or at the film-solution interface.

OP 30–86. An Elemental Description of Pacific Manganese Nodules, by Benjamin W. Haynes, Stephen L. Law, and David C. Barron. Mar. Min., v. 5, No. 3, Jan. 1986, pp. 239–276. A brief description of manganese nodule morphology and mineralogy is given, and detailed information on 74 elements in Pacific manganese nodules is presented. For the major elements and some minor and trace elements, the data are divided into four areas of the Pacific: the Clarion-Clipperton Fracture zone region, the mid-Pacific seamount region, other abyssal plain region (>3,000 m depth), and other seamount, ridge, and continental margin region (<3,000 m depth). For all 74 elements, data tables are presented, and for 21 elements, the data are broken down by area. Where only limited data are available for certain elements, the data are presented as a composite of the entire Pacific Ocean. The possible chemical form, mineral-element associations, and interelement correlations are given.

OP 31–86. Homotropal Ventilation for Longwall Dust Control, by Jonathan S. Kelly and Robert A. Jankowski. World Min. Int., v. 9, No. 12, Dec. 1985, pp. 24–26. U.S. longwall operators find compliance with federal respirable dust regulations difficult to achieve and maintain. Research has found that a major problem on many faces is contamination of the face intake air. Most U.S. longwall faces are currently ventilated from headgate to tailgate. Air is routed up one or more of the headgate entries, through a crosscut, and down the face to a return entry at the tailgate, causing intake air to

become contaminated prior to entering the face. Results from this evaluation clearly showed the benefits of homotropal ventilation, as intake dust levels on the face were reduced by over 60% when compared with levels on the majority of longwall faces in the United States.

OP 32–86. New Laboratory Measurement Method for Water Spray Dust Control Effectiveness, by J. F. McCoy, W. E. Schroeder, S. R. Rajan, S. K. Ruggieri, and F. N. Kissell. Am. Ind. Hyg. Assoc. J., v. 46, No. 12, Dec. 1985, pp. 735–740. An innovative method for measuring dust reduction is presented. The approach involves measuring dust as it is introduced into a well-mixed chamber instead of into a tunnel. The technique is equivalent to measuring the product of airflow and dust reduction efficiency of scrubbers, filters, and electrostatic precipitators; it is especially convenient in evaluating the effectiveness of open water sprays. The method, which monitors the decay of dust concentration and is useful for both charged and uncharged water sprays, promises numerous benefits including the following: (1) Steady dust production is not required, (2) only single-point dust sampling is necessary, and (3) only relative dust concentration accuracy is required. Laboratories engaged in dust control development for mines and mills are encouraged to consider adapting the measurement method for evaluating open sprays. A suitable mixed chamber can be designed, constructed, and operated with much less effort than a two-phase tunnel. Data for the dust reduction effectiveness of hydraulic and charged water sprays as well as a water-powered scrubber are presented.

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INFORMATION CIRCULAR

IC 9061. Titanium Minerals Availability—Market Economy Countries. A Minerals Availability Appraisal, by R. J. Fantel, D. A. Buckingham, and D. E. Sullivan. 1986. 48 pp. 29 figs. The Bureau of Mines investigated the resource availability of titanium minerals from 63 mines and deposits in 12 market economy countries. These mines and deposits contain, at the demonstrated resource level, an estimated 438 million metric tons (mt) of titanium dioxide (TiO_2) in the minerals rutile, ilmenite, leucoxene, and anatase. An additional 314 million mt of TiO_2 is available from inferred resources. If all titanium minerals and other recovered heavy minerals are sold at total costs at least equal to the January 1984 market prices, approximately 200 million mt of contained TiO_2 could be recovered in total. In terms of mineral concentrates, this equals approximately 11 million mt of rutile concentrate, 187 million mt of ilmenite concentrate, 3 million mt of leucoxene concentrate, 13 million mt of synthetic rutile concentrate (in addition to the ilmenite), and 89 million mt of titanium slag. The study indicates that world resources of low-cost rutile are declining. In order to maintain future supply for high-grade titanium resources, alternate sources will need to be developed, which may include higher cost rutile mines, Brazilian anatase deposits, increased production from slag operations, or more synthetic rutile capacity from ilmenite resources, which are abundant. GPO Stock No. 024–004–02159–4. $2.25.

MINERAL PERSPECTIVE

MP. Mineral Industries of Australia, Canada, and Oceania (Including a Discussion of Antarctica's Mineral Resources), by Charles L. Kimbell, Travis Q. Lyday, and Harold R. Newman. 1985. 69 pp. 43 figs. This Bureau of Mines report gives the mineral industry highlights of two of the world's major mineral producing countries, Australia and Canada, and seven Pacific island nations or territories—Fuji, New Caledonia, New Zealand, Papua New Guinea, Republic of Nauru, Solomon Islands, and Vanuatu. The mineral resources of Antarctica are also discussed. Because of the size of the Australian and Canadian mineral industries, summary reviews are presented for each of the States, Provinces, or Territories. The most current information available from all nations is given on major minerals or mineral commodity production, share of world production, and reserves. Reported also are significant mining companies, locations and capacities of their main facilities, and their share of domestic production. Other information is provided on mineral related trade with the United States, government mineral policy, energy production-consumption and trade, the mining industry labor force, and prospects for the mineral industry. Maps show the locations of selected mineral deposits, oilfields and gasfields, mines, and processing facilities including iron and steel plants, nonferrous smelters and refineries, and cement plants, as well as infrastructure pertinent to the mineral industry. GPO Stock No. 024–004–02160–8. $6.

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SPECIAL PUBLICATION

SP 3–85. Availability of Federal Land for Mineral Exploration and Development in Western States: Colorado, 1984, by Richard A. Beach, Arthur W. Gray, Eileen K. Peterson, and Clark A. Roberts. 1985. 40 pp. 13 figs. The Bureau of Mines inventoried and classified Federal land in Colorado to show its availability for mineral exploration and development, determined areas of the State that are favorable for deposits of certain minerals, and compared Federal land availability with mineral favorability to demonstrate the extent of restricted Federal land in favorable areas. Colorado has 24.7 million acres of Federal land (37.2% of the State). About 5.22 million acres of Federal land is favorable for selected metallic and nonmetallic minerals, of which 78.3% is available and 21.7% is unavailable or severely restricted. About 2.63 million acres is favorable for uranium (and partly for vanadium); 72.4% is available and 27.6% is unavailable or severely restricted. About 7.02 million acres is favorable for and 9.90 million acres more is permissible for (capable of containing) oil and gas; 73.9% is available and 26.1% is unavailable or severely restricted. About 6.31 million acres is favorable for coal, 1.02 million acres for oil shale, and 0.25 million acres for the aluminum minerals alunite and dawsonite; as of July 1, 1984, all Federal land not already leased for these minerals is unavailable. Part of the available Federal land is subject to less stringent restrictions. GPO Stock No. 024–004–02157–8. $7.

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REPORTS OF INVESTIGATIONS

RI 9008. Delayed Blasting Tests To Improve Highwall Stability—A Final Report, by Virgil J. Stachura, Larry R. Fletcher, and Michael A. Peltier. 1986. 12 pp. 14 figs. The Bureau of Mines conducted a series of delayed blasting

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experiments at a Barbour County, WV, contour coal mine that resulted in smoother highwalls. The highwalls were smoother owing to reduced overbreak (excessive rock breakage beyond the excavation limit) and were inherently safer owing to reduced likelihood of rockfall. The experiments were directed at reducing overbreak without special drilling or significant additional cost. Reduced overbreak was accomplished by increasing the highwall hole delays, which changed the effective delay pattern geometry and the direction of burden movement. Three test combinations of blast delays were used in the highwall holes: (1) 50 ms longer than the nominal design, (2) 100 ms longer than nominal, and (3) 50 and 100 ms longer in the two rows of holes nearest the highwall. The mine's nominal blast design was a flat V pattern with 17-ms surface delays between holes, 42-ms surface delays between rows, and 200-ms in-the-hole delays. All three test designs produced highwall improvements, compared with results using the nominal design, with occasional exceptions because of geologic variations. Observations and terrestrial photogrammetry showed that the delay changes produced generally smoother vertical profiles with less loose material.

RI 9009. Geotechnology in Slate Quarry Operations, by Noel N. Moebs, Gary P. Sames, and Thomas E. Marshall. 1986. 38 pp. 37 figs. This report summarizes a Bureau of Mines study on the use of geotechnology to identify and reduce ground control hazards at slate quarry operations in eastern Pennsylvania. The major ground control hazard is falling rock, attributed to weathered bedding plane faults, which weaken quarry highwalls. It was demonstrated that these faults can be detected outside of the quarry perimeter using surface resistivity measurements. Falls of ice from quarry highwalls constitute a second major hazard, which requires water diversion as a basic control method. In situ stresses seemingly cause only minor problems in slate extraction although they could interact with developed stresses and lead to failure of barriers between quarries. Pull tests showed that rockbolts anchor firmly in slate and should prove effective in securing loose rock.

INFORMATION CIRCULARS

IC 9062. Microcomputer-Based Instrumentation System for Monitoring Ground Support in a Deep Mine Shaft, by J. K. Whyatt and E. L. Hardin. 1986. 88 pp. 18 figs. This report describes a microcomputer-based instrumentation system for structural monitoring of the circular, concrete-lined Silver Shaft in northern Idaho. The 1-ft-thick concrete lining and surrounding rock mass were instrumented with a total of 12 multiple-point borehole extensometers, 16 pressure cells, 22 concrete embedment strain gauges, and 12 thermistors. The instruments were distributed among four test sites and installed immediately above the shaft bottom during sinking at the 2414, 4063, 5191, and 5955 levels. Limited access to the instruments prompted the development of a microcomputer-based remote data acquisition system that could be operated from the surface. The system scanned the instruments on a programmed schedule, printed out reduced data, and stored the data for plotting and recall. Data acquisition from off-site and uploading of data to mainframe computers were accomplished by the addition of modems to the basic system. The system is suitable for use in monitoring the structural behavior of any deep mine opening, especially in harsh operating environments and where access is limited.

IC 9063. Computer Simulation of Oxygen Requirements for Evacuating Miners, by John C. Edwards and Glenn N. Grannemann. 1986. 42 pp. 1 fig. The Bureau of Mines developed a mathematical model to predict the oxygen requirements for a miner evacuating a mine. The model accounts for variations in the miner's escape speed with mine airway height, and for the empirically determined expressions for the weight-specific oxygen uptake rate for upright walking, stooped walking (duck-walking), and crawling. A Fortran computer program that is user oriented was prepared based upon the model's constitutive equations. Specific instructions for utilizing the program, as well as applications to miner evacuation from a mine, are presented.

IC 9064. Short-Delay Blasting in Underground Coal Mines, by Richard J. Mainiero and Harry C. Verakis. 1986. 12 pp. 9 figs. The Bureau of Mines has conducted research to determine whether the total elapsed delay time for blasting bituminous coal in underground mines could be safely expanded beyond the present 500-ms limitation without igniting a methane or methane-coal dust atmosphere. The results indicated that the increase of total delay from 500 to 1,000 ms had no detectable effect on safety relative to incendivity as long as permissible practices were observed in all other aspects. Research was also conducted to evaluate the safety of 18-in hole spacing for delay blasting in coal relative to misfires. For a variety of permissible explosives, misfires were observed for about 50 pct of the holes at 18-in spacing. Based on this observation, the Bureau has recommended that the new regulations prohibit hole spacings of less than 24 inches in underground coal mines. Misfires were also observed for 24-in spacing, but the number of misfires and test shots was too small to support any firm conclusions.

IC 9065. Evaluation of Safety Shutoff Valve System on Methane Gas Pipelines Under Mine Fire Conditions, by Patrick A. Kinek, Thomas E. Marshall, and Gerald L. Finfinger. 1986. 7 pp. 4 figs. The purpose of this investigation was to evaluate the integrity of the existing shutoff valves and actuators used under high-temperature conditions in the Bureau of Mines' horizontal borehole methane drainage pipeline system and to determine the potential for improvement in the system. In the field tests, both firesafe ball valves and standard brass ball valves were initially subjected to a 30-min pan fire without thermal protection. Neither valve could maintain line pressure beyond 11 min in a fire that reached temperatures between 500° and 700° C. Based on the test results, it was concluded that the brass ball valve used in the Bureau's methane drainage pipeline system can be retrofitted with an inexpensive "fire bag" to substantially increase its integrity under mine fire conditions.

IC 9066. Longwall Roof Support Technology in the Eighties. A State-of-the-Art Report, by Ernest A. Curth and Jeffrey M. Listak. 1986. 43 pp. 36 figs. It took only 9 years from the first appearance of roof shields on the U.S. longwall mining scene to the present predominance of shield faces. An apparent consequence is the welcome downward trend in accidents related to failures in longwall ground control. The report addresses load prediction, the effects of shield geometry on support loads, factors contributing to ground control, and related techniques. The Bureau of Mines took an active part in the evolution of longwall mining, including developing one of the first shield faces in 1975, the first lemniscate-type shields in 1976, the Mine Roof Simulator completed in 1980, the first shields in steeply pitching coalbeds in 1981, and the first multilift working of a thick coalbed in 1982. The information offered in this state-of-the-art report will assist in establishing criteria for roof support selection.

PREPRINTS FROM MINERALS YEARBOOK, 1984

These preprints are chapters from Minerals Yearbook, 1984. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

The Mineral Industry of Connecticut, by L. J. Prosser, Jr., and R. J. Altamura. 8 pp. 1 fig.

The Mineral Industry of Delaware, by William A. Bonin. 7 pp. 1 fig.

The Mineral Industry of Hawaii, by Herbert R. Babitzke. 5 pp. 1 fig.

The Mineral Industry of Japan, by John C. Wu. 27 pp.

The Mineral Industry of Maine, by L. J. Prosser, Walter Anderson, and Carolyn Lepage. 8 pp. 2 figs.

The Mineral Industry of Mississippi, by James R. Boyle, Maylene E. Hubbard, and Alvin R. Bicker. 10 pp. 2 figs.

The Mineral Industry of New Hampshire, by L. J. Prosser, Jr., and Lincoln R. Page. 5 pp.
The Mineral Industry of Other Areas of the Far East and South Asia, by E. Chin, Charles L. Kimbell, Gordon L. Kinney, and John C. Wu. 37 pp.
The Mineral Industry of Turkey, by George J. Coakley and Kevin Connor. 14 pp.
The Mineral Industry of the U.S.S.R., by Richard M. Levine. 36 pp.
Minerals in the World Economy, by Charles L. Kimbell and William L. Zajac. 34 pp.

MINERAL ISSUES

MI. The Chromium Industry of the U.S.S.R., by Vasilii V. Strishkov and Walter G. Steblez. 1985. 33 pp. 8 figs. As a major world producer and exporter of chromite, the U.S.S.R. possesses sufficient chromite reserves to meet its long-term requirements. Recent declines in Soviet chromite production growth and in exports have raised the issue of the U.S.S.R.'s prospective future as a world supplier. This Bureau of Mines report provides a description of the salient characteristics of the U.S.S.R. chromium industry including the raw material base, mining and processing facilities, foreign trade, and policies and programs controlling its operations, and outlook for the future.

III. Open File Reports—NTIS

An open file report is an unpublished Bureau of Mines report that has been made available as reference material. Any open file report may be inspected during working hours at the locations indicated but may not be removed, except that the Natural Resources Library, U.S. Department of the Interior, Washington, DC 20240, can usually supply copies on interlibrary loan. The Natural Resources Library will also reproduce up to 25 pages without charge and under some circumstances can provide microfiche; contact the Chief, Circulation and Interlibrary Loan, 202–343–5815, for further information on any of these services.

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AFOC/A	**Alaska Field Operations Center, USBM, Anchorage, AK.**
AFOC/F	**Alaska Field Operations Center, USBM, Fairbanks, AK.**
AFOC/J	**Alaska Field Operations Center, USBM, Juneau, AK.**
ALRC	**Albany Research Center, USBM, Albany, OR.**
AVRC	**Avondale Research Center, USBM, Avondale, MD.**
DOI	**U.S. Department of the Interior.**
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RERC	**Reno Research Center, USBM, Reno, NV.**
RORC	**Rolla Research Center, USBM, Rolla, MO.**
SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 110–85. Improved Oxygen Sources for Breathing Apparatus—Final Report, by Peter C. Wood and Theodore Wydeven. Aug. 1983. 160 pp. 23 figs. This report describes research directed toward the preparation of chemical oxygen (O_2) sources that exhibited improved O_2 storage and reaction characteristics when compared with potassium superoxide (KO_2). The initial focus of the research was the preparation of calcium superoxide ($Ca(O_2)_2$) by the disproportionation of calcium peroxide diperoxyhydrate. The $Ca(O_2)_2$ was characterized by chemical, thermal, and X-ray analyses. Several methods for scaling up the $Ca(O_2)_2$ synthesis process were studied. Next, the reactivity of $Ca(O_2)_2$ toward humidified carbon dioxide (CO_2) was evaluated and was compared with that of KO_2 under flow-test conditions approximating those existing in portable breathing apparatus. The reactivities of mixtures of KO_2 and $Ca(O_2)_2$ or lithium peroxide toward humidified CO_2 were also studied. Finally, an analysis of two commercial, KO_2-based, self-contained self-rescuers was conducted to determine the potential weight and volume savings that would be possible if $Ca(O_2)_2$ or a mixture of KO_2 and $Ca(O_2)_2$ were used as a replacement for KO_2. Research was done under contract H0242047 by the National Aeronautics and Space Administration Ames Research Center. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: N 85–35623; paper copy price code A08. $16.95.

OFR 113–85. Products of the Oxidative Thermal Degradation of Elastomeric Noise Abatement Materials and Woods, by K. L. Paciorek, R. H. Kratzer, J. H. Nakahara, D. H. Harris, and S. R. Ahmed. Apr. 1982. 152 pp. 81 figs. The primary objective of this program was to determine the toxic fume and fire hazards of elastomeric noise abatement materials with a limited effort expended on the evaluation of specific treatments applied to mine timbers. Under the conditions employed, the major toxic hazard for a dimethyl silicone rubber was formaldehyde; for both polyester and polyether urethanes and an acrylonitrile-butadiene-styrene resin, acrolein; for flame-retardant styrene-butadiene rubber compositions, hydrogen chloride; and for Pyresote-Firehold 10-Albi 144-treated timber, furfural. Of the materials studied, the flame-retardant styrene-butadiene rubbers presented the greatest toxic hazard. The generated data have been reduced to toxic load tabulations amenable to employment for potential hazard assessment. Research was done under contract J0395008 by Ultrasystems, Inc. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC,

TCRC, and TURC. Order ONLY from NTIS: PB 86-160199; paper copy price code A08. $16.95.

OFR 126-85. Improved Skips, Guide Alignment, Dynamics, and Economics, by F. A. Penning. Feb. 1985. 315 pp. 126 figs. A comprehensive study of high-speed hoisting in deep shafts was conducted. The study (1) demonstrated the practicality of lightweight skips, (2) developed a guide alignment measuring system, (3) identified the factors affecting skip-guide, skip-rope dynamic interaction, and (4) presented the economic benefits of using lightweight skips. Two lightweight cylindrical skips, one of aluminum and one of fiberglass, were designed, fabricated, and tested. A self-contained guide alignment measuring system was conceived, fabricated, tested, and used to make field measurements in an operating shaft. A computer program (SKIP II) was used to find the effect of misaligned guides for any size skip, empty or full, at any speed. An economic analysis of lightweight cylindrical hoists focused on the impacts on capital and operating costs in hoist plant and rope life. Research was done under contract H0282013 by the Colorado School of Mines. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-152006; paper copy price code A14. $28.95.

OFR 130(1)-85. High Reliability Miner Hydraulic System. Volume I—Part I, by Staff, Fluid Power Research Center, Oklahoma State University. Feb. 1983. 270 pp. 102 figs. Research was conducted to develop methods for improving the reliability of hydraulic systems in underground coal mining equipment. Major causes of poor reliability were (1) poor overall system design, (2) poor component contamination tolerance, (3) poor system filtration, and (4) poor maintenance practices stemming from a lack of defined maintenance procedures and enforcement of same. Volume I—Part I describes the development of a computer model to aid in hydraulic system evaluation, the design study of a prototype continuous miner-bolter, the contaminant sensitivity testing of pumps, and the evaluation of conduits, filters, cylinders and seals, fluids, and reservoirs. Research was done under contract J0333948 by the Fluid Power Research Center, Oklahoma State University. Available for reference at ALRC, AVRC, DRC, LIB, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: DE 83-010312; paper copy price code A12. $22.95.

OFR 130(2)-85. High Reliability Miner Hydraulic System. Volume I—Part II, by Staff, Fluid Power Research Center, Oklahoma State University. Feb. 1983. 242 pp. 102 figs. Research was conducted to develop methods for improving the reliability of hydraulic systems in underground coal mining equipment. Major causes of poor reliability were (1) poor overall system design, (2) poor component contamination tolerance, (3) poor system filtration, and (4) poor maintenance practices stemming from a lack of defined maintenance procedures and enforcement of same. Volume I—Part II describes the evaluation of valves, the diagnosis of particulate contamination, the reliability analysis of selected hydraulic components of the conveyor and roof drill subsystems of a prototype continuous miner-bolter, and reliability analysis of common continuous miner hydraulic systems. Research was done under contract J0333948 by the Fluid Power Research Center, Oklahoma State University. Available for reference at ALRC, AVRC, DRC, LIB, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: DE 83-010313; paper copy price code A11. $22.95.

OFR 130(3)-85. High Reliability Miner Hydraulic System. Volume II—Mining Hydraulics Manual, by Staff, Fluid Power Research Center, Oklahoma State University. Feb. 1983. 114 pp. 76 figs. Research was conducted to develop methods for improving the reliability of hydraulic systems in underground coal mining equipment. Major causes of poor reliability were (1) poor overall system design, (2) poor component contamination tolerance, (3) poor system filtration, and (4) poor maintenance practices stemming from a lack of defined maintenance procedures and enforcement of same. Volume II is a mining hydraulics manual containing information on hydraulic system design and the selection of hydraulic components, system fabrication aspects from the manufacturer's point of view, and hydraulic system operation and maintenance. Research was done under contract J0333948 by the Fluid Power Research Center, Oklahoma State University. Available for reference at ALRC, AVRC, DRC, LIB, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: DE 83-010314; paper copy price code A06. $16.95.

OFR 131(1)-85. Optimal Multiple Seam Dragline Operating Procedures. Volume I: Dragline Simulation Models User's Manual, by C. D. Lee, Sun W. Chow, Harry Goforth, John W. Hughes, John A. Nowak, Ronny J. Sadri, and Mary S. Sredanovic. Apr. 1984. 424 pp. 151 figs. The dragline simulation model was designed to assist the mining engineer in finding an optimal combination of operating parameters for a given combination of physical parameters. This computer model simulates the digging, spoiling, walking, deadheading, and maintenance actions of a dragline and the removal of partings and interburdens by auxiliary equipment. It works with a three-dimensional representation of the operating pit to reflect the results of digging and spoiling. These volumes contain the results from the investigation of multiple-seam coal mining using draglines. Three different coal mining regions of the United States were visited to obtain data and provide examples of typical mining operations. Two operating mines were computer simulated during the study to validate the computer model and gain experience in the program's operation. Results indicate that most operating mines can benefit from computer simulation and subsequent implementation of computer-tested optimization procedures. Volume I consists of the user's manual for the dragline simulation model. Research was done under contract J0233903 by Fluor Engineers, Inc. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86-164282; paper copy price code A19. $34.95.

OFR 131(2)-85. Optimal Multiple Seam Dragline Operating Procedures. Volume II: Appendices, by C. D. Lee, Sun W. Chow, Harry Goforth, John W. Hughes, John A. Nowak, Ronny J. Sadri, and Mary S. Sredanovic. Apr. 1984. 324 pp. 20 figs. The dragline simulation model was designed to assist the mining engineer in finding an optimal combination of operating parameters for a given combination of physical parameters. This computer simulates the digging, spoiling, walking, deadheading, and maintenance actions of a dragline and the removal of partings and interburdens by auxiliary equipment. It works with a three-dimensional representation of the operating pit to reflect the results of digging and spoiling. These volumes contain the results from the investigation of multiple-seam coal mining using draglines. Three different coal mining regions of the United States were visited to obtain data and provide examples of typical mining operations. Two operating mines were computer simulated during the study to validate the computer model and gain experience in the program's operation. Results indicate that most operating mines can benefit from computer simulation and subsequent implementation of computer-tested optimization procedures. Volume II consists of appendices containing computer printouts and programmer aids. Research was done under contract J0233903 by Fluor Engineers, Inc. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86-164290; paper copy price code A15. $28.95.

OFR 132-85. A Borehole Probe for In Situ Neutron Activation Analysis, by J. A. Baicker, D. B. Lister, R. E. Marr III, and L. H. Goldman. June 1984. 119 pp. 29 figs. A prototype borehole probe for ore grade determinations by means of in situ neutron activation analysis was designed, built, and tested in a two-phase program. Phase I dealt with the design and fabrication of a borehole logging system for operation in 7.6 cm (3 in) diameter or larger boreholes. It consisted of a 5.06 cm (2 in) diameter borehole probe containing an intrinsic germanium detector, a canister-type solid cryogen cooling system, cooled field-effect transistor preamplifier, linear amplifier, high voltage supply, analog-to-digital converter, microprocessor-based mul-

tichannel analyzer, buffer memory, bidirectional cable link, power supplies, and a californium-252 neutron source. A surface support vehicle was designed and outfitted. A minicomputer system was constructed, and software was developed and tested. In phase II, the system was field tested at several minesites. The system was calibrated, tested, improved, and demonstrated in a variety of applications. Tests were performed at sites pertinent to uranium, iron, coal, copper, silver, and gold. Technical feasibility was demonstrated for all these applications except gold; the gold results were inconclusive. In situ neutron activation analysis using high resolution gamma ray spectrometry was found to be a potentially viable logging method for ore grade analysis under certain conditions. Research was done under contract H0262045 by Princeton Gamma Tech, Inc. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–150133; paper copy price code A06. $16.95.

OFR 133–85. A Study of Design and Development of a Coal Injector for Coarse Slurry Transport, by Boyd Wise, Sam Bell, and Dennis Thompson. May 1985. 358 pp. 101 figs. A jet pump injector was developed and successfully tested, thereby demonstrating the feasibility of a jet injector for introducing coarse coal into an operating slurry face haulage system. In phase I, a variety of injection concepts were evaluated, and the jet pump was identified as best, owing to its simplicity, compactness, and performance potential. In phase IIA, subscale jet pump injector tests were conducted, and a computer model of a jet pump injector was developed whose performance predictions correlated well with subscale test results. In phase IIB, various system configurations were defined for integrating a jet pump injector into a fully operational underground coarse slurry face haulage system, further highlighting the feasibility and practicality of such a system. In phase III, a full-scale mobile haulage vehicle embodying a jet pump injector and coal sizing equipment was detail designed into a practical vehicle with attractive performance characteristics. More importantly, fully operational full-scale jet pump injector and feeder-breaker subassemblies were tested and proven successful in their ability to down-size coal to 3 inches in all three dimensions and to consistently provide slurry of 42% weight concentration at 6.4 t/min throughout under a wide range of operating conditions including zero to maximum feed rate within 5 s. Research was done under contract J0333920 by Ingersoll-Rand Research, Inc. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–159464; paper copy price code A16. $28.95

OFR 2–86. Castings Made With Hard-Particle Dispersions and Facecoats, by J. C. Benz and J. S. Hansen. Oct. 1985. 23 pp. 4 figs. Ingots with hard-particle dispersions were produced by vacuum arc melting hollow steel cylinders containing compacted hard particles. Attempts to disperse Cr_3C_2, B_4C, or WC in AISI 4130 and 4340 steel resulted in the dissociation of these carbides and the formation of new phases within solid solutions containing the dissolved elements. TiC and TiB_2 additions remained intact as discrete particles dispersed throughout the matrix but failed to yield significantly increased wear resistance. Cast-on hard facings were produced by casting AISI 4340 steel into investment molds with hard particles adhered to the mold inner faces. Using the lost-wax investment molding process, together with vacuum arc melting and cold-mold centrifugal casting, conical coal cutter bits of the type used on continuous mining machines were produced with cast-on hard facings. Essentially void-free and tightly bonded hard facings of Cr_3C_2, Cr_7C_3, and WC were achieved, but TiC, B_4C, and TiB_2 hard facings were marked by gas-related defects and discontinuous interfacial bonding. The chromium and tungsten carbide facings proved to be too thin to provide notable protection to substrates. Research was done by the U.S. Bureau of Mines Albany Research Center. Available for reference at ALRC, AVRC, LIB, PRC/B, RERC, RORC, SLRC, and TURC. Order ONLY from NTIS: PB 86–151875; paper copy price code A02. $9.95.

OFR 11–86. High-Pressure Distillation of Crude $ZrCl_4$, by R. L. Skaggs, J. Younghans, Daniel T. Rogers, and D. B. Hunter. Aug. 1983. 41 pp. 12 figs. A high-pressure fractionation column for separation of $HfCl_4$ and $ZrCl_4$ was built to evaluate the claims of a 1976 Japanese patent (76 65,093). A 35.5-in by ¾-in-ID stainless steel 316 column packed with Inconel 600 helices was operated at 40 kg/cm² (39 atm) pressure with reboiler and overhead condenser temperatures of 471° and 455° C, respectively. The total reflux operation produced $ZrCl_4$, with 800 mol ppm $HfCl_4$ in the reboiler and with 5.2 mol pct $HfCl_4$ in the overhead. A 4.7-in height equivalent to a theoretical plate was determined using a variable separation factor. Although column corrosion partially obscured the redistribution tendencies of impurities, uranium clearly stayed in the reboiler. Of the potential construction metals exposed during distillation, Inconel 625 and Hastelloy C-276 showed the least corrosion. Research was done at the U.S. Bureau of Mines Albany Research Center. Available for reference at AD/MMR, ALRC, AVRC, LIB, PRC/B, RERC, RORC, SLRC, and TURC. Order ONLY from NTIS: PB 86–158078; paper copy price code A03. $9.95.

OFR 12–86. Wire Hoist Rope Tensile Fatigue Testing Machine, by Lee J. Raabe. Mar. 1984. 77 pp. 20 figs. A specialized loading system for tensile and fatigue testing of wire rope was constructed and installed in the U.S. Bureau of Mines Wire Rope Test Facility in Bruceton, PA. The computer-controlled closed-loop servohydraulic test system, which can apply up to 800,000 pounds of force on the rope while stretching it up to 30 inches, will be used in the development and verification of hoist rope retirement criteria for ropes in the 1- to 2½-in-diam range. Characteristics and capabilities of the system are discussed. Research was done under contract H0123016 by MTS Systems Corp. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–158029; paper copy price code A05. $11.95.

OFR 13–86. Development of Environmentally Attractive Leachants. Volume IV, A Minitest of an In Situ Uranium Leach Solution, by Robert S. Schechter, Larry W. Lake, Terry R. Guilinger, Jonathan G. Price, and Patricia Bobeck. July 1985. 150 pp. 50 figs. A minitest of the new potassium chloride-potassium carbonate two-stage in situ uranium leach process has been carried out at the Intercontinental Energy Corp. Zamzow project site in south Texas. Substantial quantities of high concentration uranium were produced, indicating the viability of the leach solution. The test results yield information regarding the reservoir dispersivity, the average cation-exchange capacity of the formation, and the distribution coefficients describing cation-exchange reactions. The test also indicates permeability anisotropy and the existence of disturbed flow fields. Research was done under contract H0282016 at the University of Texas at Austin. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–158789; paper copy price code A08. $16.95.

OFR 14–86. Development of Effective Face Ventilation Systems for Oil Shale Mining, by C. E. Brechtel, M. E. Adam, and J. F. T. Agapito. Oct. 1985. 148 pp. 24 figs. This project describes the design and testing of large face ventilation systems for oil shale mining. A design data base was generated by reviewing general industry practice, oil shale industry planning, and technical literature. Conceptual designs for seven different systems were developed and evaluated for suitability. A large, freestanding, jet fan and reversible fan with rigid duct were selected for fabrication and testing. The two systems were field tested in a dead-end heading 55 ft wide by 30 ft high and 320 ft long. System performance was optimized using measurements of airflow direction and air velocity. Total system performance was then measured using SF_6 tracer gas released to simulate blast fumes, hot diesel exhaust, methane layering, and methane from a blasted muckpile. Field testing indicated that both systems delivered similar performance. The jet fan offered some clear advantages because of its mobility, ease of operation, and lower power requirement. It also offered some

functional advantages in ventilating for methane because of its high average velocity. Research was done under contract H0134033 by J. F. T. Agapito & Associates, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–159829; paper copy price code A07. $16.95.

OFR 17–86. Results of 1984 Bureau of Mines Site Specific Field Studies Within the Willow Creek Mining District, Alaska, by Joseph M. Kurtak. 1986. 17 pp. 4 figs. The Bureau of Mines conducted mineral investigations of specific sites in the Hatcher Pass area of the Willow Creek Mining District in Alaska during 1984. The Hatcher Pass area has produced over 400,000 oz of gold, mainly from lode deposits and some minor placer production. Out of approximately 40 properties in the area, 9 were visited, including several active operations. Random samples were collected for analysis and mineral identification. Discussions with local miners identified several problem areas concerning metallurgy, recovery, and mining feasibility. Research was done by the U.S. Bureau of Mines Alaska Field Operations Center. Available for reference at AFOC/J, IFOC, LIB, PRC/B, and WFOC. Order ONLY from NTIS: PB 86–163904; paper copy price code A02. $9.95.

OFR 18–86. Improved Diffuser and Sprayfan Systems for Ventilation of Coal Mine Working Faces, by S. K. Ruggieri, T. L. Muldoon, C. Babbitt, and Ed Lee. July 1985. 292 pp. 95 figs. This report describes the laboratory development and testing of the improved sprayfan auxiliary ventilation system. The sprayfan system, based on the fact that water sprays can move air like small fans, consists of several spray manifolds strategically placed on continuous miners to direct intake air to the face and sweep contaminated air (methane and dust) across the face to the return. Water spray systems using sprayfan principles have been installed on more than 300 continuous miners. Although the improved sprayfan system operates on the same principles as the original sprayfan system, the layout and number of spray nozzles differ, providing additional water for dust suppression. A detailed description of the test facility, evaluation techniques, and system test results is provided in this report. The effect of methane monitor placement and instrument lag on the indicated methane reading was also assessed. The results of two major field evaluations of the improved sprayfan system are given. Research was done under contract J0113010 by Foster-Miller, Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–168440; paper copy price code A13. $22.95.

OFR 19–86. Improved Sprayfan System Installation Guide, by Steven K. Ruggieri, Chip Babbitt, and Jim Burnett. July 1985. 72 pp. 20 figs. This guide contains information on the (1) description and capabilities, (2) design, (3) installation, (4) operation, and (5) maintenance of the improved sprayfan auxiliary ventilation system. The improved sprayfan system is a modified water spray system that directs intake air to and across the front of a continuous miner to prevent buildup of methane gas and dust concentrations. Although the improved sprayfan system operates on the same principles as the original sprayfan system, the layout and number of spray nozzles differ, providing additional water for improved dust suppression. Underground tests, independent laboratory tests, tests by the Mine Safety and Health Administration, and independent installations by coal producers have confirmed the performance of the sprayfan system. More than 300 sprayfan systems are currently in operation in underground coal mines. Research was done under contract J0113010 by Foster-Miller, Inc. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–165065; paper copy price code A04. $11.95.

OFR 20–86. Development of Prototype Quiet Hard Rock Stoper Drill—Volume II, by William N. Patterson. Dec. 1985. 37 pp. 10 figs. This report describes the design and testing of an improved quiet hard-rock percussion drill. The improved drill incorporates a tappetless design with independent rotation in a handheld drill weighing 50 lb. Laboratory and field testing in three mines were conducted. The testing showed improved drilling performance with no increase in measured noise levels over the first design. Research was done under contract H0113034 by Creare Products, Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–165073; paper copy price code A03. $9.95.

OFR 21–86. Development of Noise Control Technology for Jumbo Drills, by Piyush K. Dutta and William N. Patterson. May 1985. 67 pp. 35 figs. This report describes the design, development, manufacture, and incorporation of noise control features on a jumbo drill and the results of successful tests of this drill in surface and underground mines. The noise-reducing features developed under this program are applicable to future designs of jumbo drills that can be cost effectively manufactured and have the potential to reduce noise levels at the operator's position from 115-120 dBA to 95 dBA or less without a reduction of currently attainable drilling rates. Research was done under contract H0395025 by Creare Products, Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–165081; paper copy price code A04. $11.95.

OFR 22–86. Dissolution of Galena With Ferric Chloride and Nitrate, by Maurice C. Fuerstenau. Dec. 1984. 58 pp. 30 figs. The kinetics of leaching galena with ferric chloride and ferric nitrate have been examined as a function of ferric concentration, salt concentration, temperature, and particle size. Diffusivity of ferric complex ions was also established as a function of ferric chloride concentration and temperature. In the presence of 3*M* NaCl, leaching rate is controlled by product layer diffusion when ferric chloride is added as oxidant. With NaCl concentrations less than 3 mol/L, rate decreases with decreased NaCl concentration, and thus, rate is apparently not controlled by product layer diffusion. It is suggested that rate is controlled by lead chloride solubility at the reaction interface under these conditions. When ferric nitrate is added as oxidant, leaching rate is limited by chemical reaction control. An electrochemical model is presented. Activation energies are 8.1 and 11.3 kcal/mol in the ferric chloride and ferric nitrate systems, respectively. Research was done under contract J0215026 at the South Dakota School of Mines and Technology. Available for reference at AD/MMR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–169513; paper copy price code A04. $11.95.

OFR 26–86. Development of the Claw Hammer Scaling Tool, by James D. Eklund. Dec. 1983. 25 pp. 8 figs. To improve safety, economy, and efficiency of scaling in underground metal or nonmetal mines, research was conducted to develop a combination prying-hammering tool for machine scaling. In the prototype claw-hammer assembly, a hydraulic impact hammer was used to drive the claw mechanism into the rock. After a bite was established, the loose rock could be removed using a hydraulically actuated prying motion. This tool combines the advantages of both impact and repair type scaling tools and provides versatility for use in most rock types. The prototype was subject to limited testing (1) to verify its operational functions and (2) to assess its potential capability in future underground testing. The prototype was first bench tested to hydraulically test the independent functions. It was then mounted on a backhoe boom for some preliminary field testing. Both claw and hammering functions operated successfully on concrete and quartzite boulders. Research was done under contract H0202025 by Battelle, Pacific Northwest Laboratories. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–169471; paper copy price code A03. $9.95

OFR 27–86. Domestic Consumption Trends, 1972-82, and Forecasts to 1993 for Twelve Major Metals, by U.S. Department of the Interior, Bureau of Mines staff, and U.S. Department of Commerce, Basic Industries Sector staff. January 1986. 158 pp. 45 figs. Domestic consumption and intensity of use trends for 12 metals, by industrial end use, were estimated for 1972 through 1982. The trends were then forecast through 1993 using standard statistical methods. The intensity of use measure selected is the quantity of metal consumed per constant dollar output of a specific industrial sector. The metals studied were aluminum, chromium, cobalt, copper, lead, manganese, nickel, the platinum-group metals, tin, titanium, tungsten, and zinc. Average annual growth rates for 4 of the 12 metals increased from 1972 to 1982 as follows: aluminum, 1.00%; platinum-group metals (consisting of platinum, palladium, and iridium), 8.83%; titanium, 7.82%; and tungsten, 6.09%. Consumption for the remaining eight metals decreased at annual rates ranging from 0.58% (copper) to 5.37% (manganese). Available for reference at AFOC/J, IFOC, LIB, and WFOC. Copies of this report will not be available for purchase.

OFR 28–86. 1984 Sample Results for Bureau of Mines Site Specific Mineral Investigations Within the Yentna Mining District, Alaska, by Steven A. Fechner. May 1985. 53 pp. 6 figs. In 1984, the Bureau of Mines conducted mineral investigations of specific sites within the Yentna Mining District, in which 108 placer and rock samples were taken. Reconnaissance placer samples were collected from drainages in the Talkeetna, Susitna, and Yentna River basins. The highest placer gold values were found in the historic placer gold producing creeks of the Cache-Peters Creek area. Samples taken from an outcrop in the Middle Fork of Iron Creek in the Talkeetna Mountains contained previously unreported high lead, zinc, and silver values. Research was done by the U.S. Bureau of Mines Alaska Field Operations Center. Available for reference at AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 86–168838; paper copy price code A04. $11.95.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 12–86. Mineral Resources of the Owyhee Canyon Study Area, Elko County, Nevada, by Donald O. Capstick and Alan R. Buehler. 1986. 9 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 13–86. Mineral Resources of the Pahute Peak Wilderness Study Area, Humbolt County, Nevada, by Jerry E. Olson. 1986. 20 pp. 3 figs. Western Field Operations Center, Spokane, WA.

MLA 14–86. Mineral Resources of the Antelope Wilderness Study Area, Nye County, Nevada, by Frederick L. Johnson and David A. Benjamin. 1986. 16 pp. 6 figs. Western Field Operations Center, Spokane, WA.

MLA 15–86. Mineral Resources of the Lick Creek Roadless Study Area, Valley County, Idaho, by Michael C. Horn. 1986. 9 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 16–86. Mineral Resources of a Part of the Big Hatchet Mountains Wilderness Study Area (NM–030–035), Hidalgo County, New Mexico, by David C. Scott. 1986. 31 pp. 8 figs. Intermountain Field Operations Center, Denver, CO.

MLA 17–86. Mineral Investigation of the Antelope Wilderness Study Area (NM–020–053), Socorro County, New Mexico, by Stanley L. Korzeb. 1986. 6 pp. 1 fig. Intermountain Field Operations Center, Denver, CO.

MLA 19–86. Mineral Investigation of the Southern Nantahala Wilderness Area, Rabun and Towns Counties, Georgia, and Clay and Macon Counties, North Carolina, by Brian J. Hannigan. 1986. 16 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MLA 20–86. Mineral Resources of the Ojito Wilderness Study Area (NM–010–024), Sandoval County, New Mexico, by Steven E. Tuftin. 1986. 11 pp. 4 figs. Intermountain Field Operations Center, Denver, CO.

MLA 21–86. Mineral Investigation of the Jornada del Muerto Wilderness Study Area (NM–020–055), Sierra and Socorro Counties, New Mexico, by George S. Ryan. 1986. 12 pp. 4 figs. Intermountain Field Operations Center, Denver, CO.

MLA 22–86. Mineral Resources of the Owyhee Canyon Study Area, Malheur County, Oregon, by J. Mitchell Linne. 1986. 14 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 23–86. Mineral Resources of the Fish Creek Mountains Wilderness Study Area, Imperial County, California, by Harry W. Campbell. 1986. 22 pp. 4 figs. Western Field Operations Center, Spokane, WA.

MLA 26–86. Mineral Resources of the Blacktail Mountains Study Area, Beaverhead County, Montana, by John R. Benham. 1986. 14 pp. 2 figs. Western Field Operations Center, Spokane, WA.

IV. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 33–86. A Review of Techniques for Evaluating Mine Roof Competence, by E. R. Bauer and J. B. Czirr. Soc. Min. Eng. AIME preprint 86–44, 1986, 6 pp. A primary goal of Ground Control Research, Bureau of Mines, U.S. Department of the Interior, is to develop information that can be used by the mining industry to reduce accidents and fatalities due to failure of mine roof. A specific research objective is to determine methods to detect hazardous coal mine roof. This paper reviews the existing and experimental techniques and describes a recent Bureau of Mines contract research project that resulted in a simple technique and prototype instrument for evaluating mine roof competence.

OP 34–86. Treatment of Metalliferous Sulfides for Market, by Thomas G. Carnahan. Mar. Technol. Soc. J., v. 19, No. 4, 1985, pp. 62–64. Base metal sulfide deposits are known to exist in the Pacific Ocean and in the Red Sea. Sufficient data have been generated to allow a preliminary assessment of potential processing techniques. The course nature of the Pacific Ocean sulfide minerals indicates that conventional flotation will enable separate smelter-grade copper and zinc concentrates to be prepared. On-land smelting would produce these metals. The extremely fine-grained nature of the Red Sea deposits precludes preparation of smelter-grade flotation concentrates. The Red Sea concentrates would be treated for metals recovery by a chloride-based hydrometallurgical method.

OP 35–86. Control and Monitoring Via Medium-Frequency Techniques and Existing Mine Conductors, by Harry Dobroski, Jr., and Larry G. Stolarczyk. IEEE Trans. Ind. Appl., v. IA–21, No. 4, July-Aug. 1985, pp. 1087–1092. Medium-frequency (MF) techniques have been successfully applied to the problem of radio voice communications in both coal and metal and nonmetal mines. Long range is achieved by taking advantage of existing mine conductors that carry and propagate the signal over vast areas. It is very likely that in the

near future such systems will become the preferred method for general mine communications. MF techniques can also be applied to the areas of in-mine control and monitoring. Preliminary work in this area is described. In a western mine, locomotives are being operated under MF remote control in a loading operation. In several eastern mines, MF has been evaluated as a method for monitoring the status of devices in remote areas of the mines. All control and monitor information uses existing mine conductors.

OP 36–86. Acid Mine Drainage From Inactive Eastern Coal Operations, by Patricia M. Erickson, Kenneth J. Ladwig, and Robert L. P. Kleinmann. Environ. Geochem. and Health, v. 7, No. 1, Mar. 1985, pp. 16–25. The most widely used technique for abatement of acid drainage from inactive surface mines and refuse disposal areas is revegetation of a soil cover applied to the waste material. Nonetheless, acid production often persists and, in some cases, limits establishment of vegetation. This paper reports on several field studies intended to determine the location of pyrite oxidation zones and migration pathways of oxidation products at inactive spoil and refuse sites. Oxygen required for pyrite oxidation is believed to be provided in the gaseous state from the atmosphere. Therefore, the oxygen concentration in unsaturated mine waste should provide an estimate of the weathering tendency in the local environment. Gas composition is currently being monitored in refuse and spoil at six sites. Barren refuse appeared to be oxygenated (>2% O_2) in a shallow zone extending less than 1 meter below the surface during most of the year. Preliminary data from coal spoil showed that oxygen can be available throughout the unsaturated thickness, even at a revegetated site. Gas composition varied vertically and laterally at a single site and also appeared to show seasonal dependence. Hydrologic factors are also important in acid production and transport. Discharge monitoring alone does not adequately describe the mass transport of acid products through the spoil. For example, at one reclaimed mine, the mean sulfate content in six monitoring wells ranged from 24% to 240% of the mean concentration at the discharge point. Sources of recharge and relative flow rates determine the contribution of a particular zone to overall discharge quality. These basic studies of acid production and transport indicate some shortcomings of standard reclamation practices at certain sites. This information will be used to develop alternative abatement technology designed to mitigate acid production at the source.

OP 37–86. Update on the Evaluation of Diesel Particulate Filters for Underground Mining, by A. Lawson, H. C. Vergeer, A. Stawsky, J. H. Daniel, and E. Thimons. Paper in the Proceedings of the 1986 SAE International Congress, Detroit, MI, Feb. 24–28, 1986, pp. 263–271. Results of a laboratory assessment of catalyzed ceramic diesel particulate filters (DPF's) are reported. Catalyzed DPF's are shown to substantially reduce diesel particulate emissions, carbon monoxide, and gaseous hydrocarbons, as well as particulate ignition temperatures. Sulfate production is discussed in relation to sulfates presently emitted into the mine environment. Field experience is reported on the application of the ceramic DPF to control diesel particulate emitted from underground diesel-powered vehicles. The vehicle has been operated in mine production service over typical load-haul-dump duty cycles. Field tests have been carried out using the filters assisted with both fuel additive and precious metal catalyst coating techniques. The structural integrity of the filter appears satisfacory with approximately 250 hours of field experience. Both manganese fuel additive and precious metal catalyst coating were shown to provide satisfactory regeneration assist. Exhaust backpressures over a 250-hour test were lower than the original exhaust system comprising an exhaust catalytic purifier and muffler in series.

OP 38–86. Biaxial-Loading Measurement for Mine-Pillar Stability Evaluation—Case Studies, by Paul H. Lu. Paper in the Proceedings of the International Symposium on Application of Rock Characterization Techniques in Mine Design, New Orleans, LA, Mar. 2–6, 1986. Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 142–151. This paper presents three case studies in which the biaxial loading was measured to evaluate the stability of longwall chain pillars. Integrity factor, defined as the ratio of the total pillar strength to the total pillar load, is the criterion for stability. The total pillar load is derived directly from the in situ measurement of vertical pressures. The total pillar strength is derived from the situ measurement of horizontal pressures and the confined compressive strengths of pillar material as determined in laboratory tests. Horizontal and vertical pressures in the pillar were measured with the Bureau of Mines, U.S. Department of the Interior, hydraulic borehole pressure cells.

OP 39–86. Crude Iodine Production—A Review of Processes, by P. A. Lyday. Ind. Miner., No. 222, Mar. 1986, pp. 65–66, 69–70, 73, 75–76. There have been three distinct but overlapping phases in the history of iodine processing. Phase 1, which began in 1817 and continued until 1959, involved iodine production from seaweed in France, Japan, Norway, Scotland, the United States, and the U.S.S.R. Phase 2 began in 1852 as byproduct production of iodine with natural sodium nitrate in Chile. Phase 3 began in 1854 with the production of iodine from brines in Java, Indonesia, and eventually in Italy, Japan, the United States and the U.S.S.R. The production of crude iodine has experienced many technical changes over the past 175 years. The changes in processing and production during these years will be discussed.

OP 40–86. Power From Mine Cooling Water, by Robert N. Torbin and Edward Thimons. Power Eng., v. 90, No. 3, Mar. 1986, pp. 27–28. The U.S. Bureau of Mines, as part of its Health and Safety Research Program, funded a research program to study the applicability of energy recovery techniques to the mining industry. Since much of the electric power consumed in the United States is generated by converting the energy from falling water, it is easy to conceive that water flowing down long, vertical pipelines into deep mines could be utilized in a similar manner by allowing the high-pressure water to operate a turbine at the bottom of the pipeline. An energy recovery system of this type can offer several advantages. Modern turbines can convert about 90% of the water's potential energy into useful shaft work. In using a turbine with an efficiency rate of 85%, the temperature rise of the water due to potential energy conversion is only 15% of the rise experienced with no turbine. Lower water temperature resulting from turbine usage can be expressed directly in tons of refrigeration (which becomes important to cooling the working environment in deep mines).

V. Patents

These patents, which may be used by any U.S. citizen or organization without royalty payment upon authorization by the U.S. Department of the Interior, were developed by Bureau scientists or under contracts with the Bureau. Application should be made to—

Branch of Patents
Division of General Law
Office of the Solicitor
U.S. Department of the Interior
Washington, DC 20240

U.S. Pat. 4,562,049. Recovery of Titanium From Perovskite by Acid Sulfation. Monte B. Shirts, Dale A. Martin, and Allan E. Peterson. Dec. 31, 1985.

U.S. Pat. 4,568,014. Bonding of Metallic Glass to Crystalline Metal. Brent W. Madsen. Feb. 4, 1986.

U.S. Pat. 4,568,652. Soluble Additives To Improve High Temperature Properties of Alumina Refractories. Arthur V. Petty, Jr. Feb. 4, 1986.

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MINERALS YEARBOOK, 1984

Volume III. Area Reports: International, 1984, prepared by the staff of the Bureau of Mines. 1986. 91 ch. 1079 pp. This volume of the 1984 Minerals Yearbook contains the latest available mineral data on more than 130 foreign countries and discusses the importance of minerals in the economies of these nations. A separate chapter reviews the international minerals industry in general and its relationship to the world economy. GPO Stock No. 024–004–02162–4. $35.

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REPORT OF INVESTIGATIONS

RI 9010. An Improved Analyzer for Determining Helium-4 in Parts-Per-Billion Range, by Charles A. Seitz and Philip W. Holland. 1986. 7 pp. 2 figs. The Bureau of Mines has modified its parts-per-billion helium-4 analyzer to improve the analytical capabilities of the instrument. The modifications resulted in the following improvements: (1) The analytical precision of the instrument for 10 consecutive analyses was improved to ±1 ppb at the 5,000-ppb helium-4 level, (2) the helium-4 sensitivity was increased almost tenfold, and (3) the minimum detectable limit for helium-4 was improved to 0.5 ppb. The modifications made to improve the instrument included replacing the ion-source control circuit with a direct-current solid-state design, controlling the temperature of the ion source, stabilizing and reducing the pumping rate of the vacuum system, and optimizing peak integration.

INFORMATION CIRCULARS

IC 9067. Results of Direct-Method Determination of the Gas Content of U.S. Coalbeds, by W. P. Diamond, John C. LaScola, and D. M. Hyman. 1986. 95 pp. 1 fig. In 1972, the Bureau of Mines developed a direct-method test for measuring the gas content of virgin coal core samples for coal mine health and safety considerations. Since that time, approximately 1,500 coal samples from more than 250 coalbeds in 17 States have been collected for gas content determination. The gas content data, when combined with geologic and engineering studies, can be used as a basis for a preliminary estimate of mine ventilation requirements, and to determine whether methane drainage in advance of mining should be considered. The data are also critical in delineating coalbed resources and in utilization feasibility studies. This report makes the Bureau's extensive data base of gas content data more readily available to the coal and gas industries. The data are presented in tabular form, alphabetically by coalbed name and by State. The components of the total gas content (lost, desorbed, and residual gas) are given. Location (State and county), sample depth, coalbed or formation name, and coal rank are included for geographic and geology identification.

IC 9068. Dust Reduction Capabilities of Five Commercially Available Bag Valves, by Andrew B. Cecala, Anthony Covelli, and Edward D. Thimons. 1986. 10 pp. 6 figs. The dust-reduction capabilities of five commercially available bag valves were evaluated by the Bureau of Mines for use in mineral processing plants. The five valves were made of (1) standard paper, (2) polyethylene, (3) extended polyethylene, (4) double trap (paper), and (5) foam. The valves were evaluated at a mineral processing plant during the bag loading, conveying, and pallet loading process. For the overall process, the extended polyethylene valve was the most effective at reducing product blowback, and resulted in lower dust concentrations for bag-generated dust. When compared to the standard paper, it gave a 62-pct reduction in respirable dust at the bag operator location, and a 66-pct reduction at the bag stacker location. The cost of the extended polyethylene valve is less than 1 cent per bag higher than that of the standard paper valve. The high dust reductions and slight cost increase make it an attractive choice for the mineral processing industry.

IC 9069. Aluminum Fluxing Salts: A Critical Review of the Chemistry and Structures of Alkali Aluminum Halides, by Charles A. Sorrell, John G. Groetsch, Jr., and D. M. Soboroff. 1986. 37 pp. 38 figs. This Bureau of Mines publication reviews the structural characteristics of crystalline phases and phase equilibria data for the system NaCl-KCl-$AlCl_3$-NaF-KF-AlF_3, which encompasses a large number of molten salt fluxes currently used in aluminum recycling. Its purpose is to provide guidelines for research into the relationships between molten salt compositions and their physical properties, notably vapor pressures, densities, surface tensions, and viscosities, knowledge of which is essential to maximizing fluxing efficiencies and metal recovery and minimizing hazardous emissions and disposal problems. In addition, this report describes experimental determinations of subsolidus compatibility relationships in the system, which is of the quaternary reciprocal type, containing 12 different stable 4-phase assemblages in the solid state. The compatibility diagram serves to define the important compositional planes across which important changes in properties are likely to occur.

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PREPRINTS FROM MINERALS YEARBOOK, 1984

These preprints are chapters from Minerals Yearbook, 1984. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

The Mineral Industry of Alabama, by James R. Boyle and Ernest A. Mancini. 17 pp. 2 figs.
The Mineral Industry of Arkansas, by James R. Boyle and William V. Bush. 13 pp. 2 figs.
The Mineral Industry of Idaho, by W. L. Rice, E. H. Bennett, and M. M. Miller. 14 pp. 2 figs.
The Mineral Industry of Illinois, by James J. Hill and Wanda J. West. 13 pp. 2 figs.
The Mineral Industry of Indiana, by William A. Bonin. 15 pp. 2 figs.
The Mineral Industry of Iowa, by James H. Aase and Wanda J. West. 10 pp. 2 figs.
The Mineral Industry of Kansas, by James J. Hill, David A. Grisafe, and Wanda J. West. 12 pp. 2 figs.
The Mineral Industry of Massachusetts, by L. J. Prosser, Jr., and Joseph A. Sinnott. 6 pp. 1 fig.
The Mineral Industry of Minnesota, by James H. Aase. 13 pp. 2 figs.
The Mineral Industry of Montana, by W. L. Rice, Henry G. McClernan, and D. C. Lawson. 12 pp. 2 figs.
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The Mineral Industry of New Jersey, by Donald K. Harrison. 10 pp. 2 figs.
The Mineral Industry of New York, by Donald K. Harrison. 12 pp. 1 fig.
The Mineral Industry of Oregon, by Herbert R. Babitzke and Howard C. Brooks. 11 pp. 2 figs.
The Mineral Industry of Puerto Rico, Caribbean and Pacific Island Possessions, and Trust Territory of the Pacific Islands, by Doss H. White, Jr., and Ivette E. Torres. 6 pp.
The Mineral Industry of Rhode Island, by L. J. Prosser, Jr. 4 pp.
The Mineral Industry of Utah, by Lorraine B. Burgin. 16 pp. 2 figs.
The Mineral Industry of Vermont, by L. J. Prosser, Jr., and Charles A. Ratté. 7 pp. 1 fig.
The Mineral Industry of Washington, by William L. Rice and Bonnie Butler Bunning. 11 pp. 2 figs.
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The Mineral Industry of Wisconsin, by James J. Hill, Thomas J. Evans, and Wanda J. West. 13 pp. 2 figs.

MINERAL INDUSTRY SURVEY

Mineral Industry Surveys dealing with various commodities will be forwarded regularly if application stating in detail the need for certain reports is made to—

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Some of these reports are issued weekly, monthly, quarterly, or annually. The following annual report was issued during April.

Directory of Companies Producing Phosphate Rock in the United States—1986. 3 pp.

III. Open File Reports—NTIS

An open file report is an unpublished Bureau of Mines report that has been made available as reference material. Any open file report may be inspected during working hours at the locations indicated but may not be removed, except that the Natural Resources Library, U.S. Department of the Interior, Washington, DC 20240, can usually supply copies on interlibrary loan. The Natural Resources Library will also reproduce up to 25 pages without charge and under some circumstances can provide microfiche; contact the Chief, Circulation and Interlibrary Loan, 202–343–5815, for further information on any of these services.

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AFOC/J	**Alaska Field Operations Center, USBM, Juneau, AK.**
ALRC	**Albany Research Center, USBM, Albany, OR.**
AVRC	**Avondale Research Center, USBM, Avondale, MD.**
DOI	**U.S. Department of the Interior.**
DRC	**Denver Research Center, USBM, Denver, CO.**
IFOC	**Intermountain Field Operations Center, USBM, Denver, CO.**
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SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
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USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 6–86. Second Generation Front-End Loader Stability Indicator, by Gilbert Wray and Jan Nazalewicz. Mar. 1985. 81 pp. 22 figs. This report describes the second stage

in the development of a stability indicating system for use in minimizing the occurrence of front-end loader (FEL) rollovers in mining. The overall development proceeded in three phases: definition of FEL stability-instability characteristics; design of a first-generation stability indicator; and design of a simplified, second-generation stability indicator, which is covered by this report. Goals met by the final design include confirmation of a simplified methodology for detecting machine instability; the ability to be installed on new loaders during manufacture or on older loaders on a retrofit basis; and reliable, easily interpretable operation. Research was done under contract J0395074 by the Stevens Institute of Technology Davidson Laboratory. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86-176419; paper copy price code A05. $11.95.

OFR 15-86. Characterization of Metal Hydroxy Silicate Dispersants, by Maurice C. Fuerstenau and John J. Fitzgerald. July 1984. 122 pp. 35 figs. Studies on the synthesis and characterization of aluminum hydroxy silicate polymers were undertaken using gel filtration chromatography, solid-state nuclear magnetic resonance spectroscopy, and other chemical analysis methods. The results of these investigations indicate that (1) hydrosols prepared at lower initial reactant concentrations at fixed Si-Al ratios produce higher levels of soluble Si-Al supernatant species, (2) hydrosols with a Si-Al ratio 6.66 to 1 contain the highest concentration of total and polymeric Al and Si in their corresponding supernatants, (3) the ratio of polymeric silicon to polymeric aluminum contents in supernatants from 6.66 to 1 hydrosols is between 7 and 9, and (4) aluminosilicate species of molecular weight range 500 to 2,000 exist in the hydrosol supernatants in addition to monomeric and polymeric silicates of a similar molecular weight range. Nuclear magnetic resonance studies of colloidal precipitates from these hydrosols are consistent with the soluble aluminosilicate and silicate species from supernatant studies. The nature and stoichiometry of the active species in a range of Si-Al hydrosols are discussed in conjunction with a chemical model of the reaction process used to prepare these systems. Research was done under contract J0123058 at the South Dakota School of Mines and Technology. Available for reference at ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86-181732; paper copy price code A06. $16.95.

OFR 29-86. Control of Respirable Quartz on Continuous Mining Sections, by J. F. Colinet, G. A. Shirey, and J. A. Kost. June 1985. 106 pp. 40 figs. This study evaluated sources of airborne quartz and research control methods that would assist underground mine operators in complying with respirable dust standards that had been reduced because of quartz in the dust exceeding 5%. The work involved (1) evaluating sources of quartz dust at the roof bolter work location, (2) evaluating the relationship between the quartz content of the coal and adjoining rock strata and quartz exposure at the roof bolter and continuous miner locations, and (3) conducting laboratory tests to determine performance parameters for roof bolter dust collector systems. Underground surveys were conducted. The continuous miner typically was the greatest source of quartz exposure for the miner and roof bolter operators when single-split ventilation was utilized. A statistically significant relationship between quartz content in face material and operator exposure was not determined; data suggested that mining equipment and procedures may be more critical. The lab tests indicated the use of dust hog-type bits, filter cartridges, maximized collector airflow, and reduced bit revolutions per minute should be utilized to minimize dust liberation at the roof bolter. Research was done under contract J0338033 by BCR National Laboratory. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86-179546; paper copy price code A06. $16.95.

OFR 30-86. Compact Service Hoist System for Underground Metal and Nonmetal Mines, by David J. Hoadley, Billy C. Brunelle, and John F. Healey. Dec. 1985. 139 pp. 7 figs. A semiautomatic, raise climber, compact service hoist system was designed for stope access in underground metal and nonmetal mines. Demonstrated capabilities of the system include a 1,000-lb payload capacity, control from the traveling cage and from up to three remote stations, and operation in vertical or inclined raises 3 ft in diameter and up to 300 ft in length at a travel speed of 50 ft/min. The system can be operated in crooked raises; the conveyance climbs two stationary wire ropes suspended down the raise. The drive unit is electrically powered, with power and control signals supplied to the drive unit through an umbilical cable also suspended down the raise. The system has been designed for portability, ease of installation, and minimum raise development. The hoist has been demonstrated successfully in an aboveground test tower. This report provides a detailed description of the hoist design and its demonstrated performance to date. Research was done under contract H0202019 by Foster-Miller, Inc. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-179991; paper copy price code A07. $16.95.

OFR 31-86. Conveyor Belt Dust Control, by Vinit Mody and Raj Jakhete. July 1984. 410 pp. 92 figs. The belt conveyor is one of the major pieces of equipment for transferring bulk material in mining operations. However, considerable amount of respirable dust may be generated whenever the bulk material is loaded, dumped, or transferred. This report identifies and evaluates various dust control technologies applicable to belt conveyors and describes how an integrated systems approach can reduce dust emissions at a transfer point. Phase I of the program consisted of a literature search and a critical evaluation of various dust control technologies. The work established that a comprehensive approach to calculating exhaust volumes for dust collection systems does not exist. The parameters that affect the wet dust suppression efficiency were also reviewed. Based on the phase I work, bulk material handling systems and dry dust collection or wet dust suppression systems were designed and installed at a number of transfer points in a limestone processing facility, a surface mine selected as a field test site. Field test data were used to determine the validity of various exhaust volume calculations at the different transfer points. The field test data also formed the basis for the evaluations of the relative effectiveness of commercially available and wet dust suppression systems in controlling respirable dust emissions. Research was done under contract H0113007 by Martin Marietta Laboratories. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 32-86. Revegetation of Coal Strip Mine Spoils in Eastern Wyoming, by Marinus L. Wouden, Lawrence J. Froisland, Delwin L. Richards, Jr., and Monte B. Shirts. Jan. 1986. 18 pp. 3 figs. In the late 1970's, the Bureau of Mines began to examine the criteria for reestablishing vegetative cover on coal strip mine spoils near Glenrock, WY. A 9-acre plot, consisting of (1) spoils covered with topsoil, (2) spoils without topsoil, and (3) spoils treated with sewage sludge, was constructed. These plots were seeded with Tegmar intermediate wheatgrass (*Agropyron intermedium*), Fairway crested wheatgrass (*A. cristatum*), and Critana thickspike wheatgrass (*A. dasystachyum*). After 5 yr, the topsoil had about 70 pct plant coverage. Revegetated spoils, without topsoil addition, averaged approximately 30 pct plant coverage, and sewage sludge-treated spoils had about 45 pct plant coverage. Comparison of grass types showed that intermediate wheatgrass produced greater surface coverages. Research was done by the Bureau of Mines Salt Lake City Research Center. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Copies of this report will not be available for purchase.

OFR 33-86. Geologic Factors Affecting Vibration From Surface Mine Blasting, by James W. Reil, Douglas A. Anderson, Andrew P. Ritter, Dennis A. Clark, S. R. Winzer,

and A. J. Petro. Sept. 1985. 204 pp. 65 figs. A test series of small, precisely controlled and thoroughly monitored production blasts was conducted at two quarries. In each series, all variables except delay were kept constant, as much as practically possible. The first aim of the study was to determine the effect of local geology on ground vibration. The second aim was to test several hypotheses relating the effect of millisecond delay intervals to fragmentation and ground vibration. A resonant frequency of ground vibration was shown to be related to the thickness of the overburden, in accord with a model proposed by Gupta. Since the overburden geology creating this resonant vibration cannot usually be changed, two methods were tested to choose delays such that blast vibrations would destructively interfere. These methods were shown to be effective in modifying both the peak particle velocity and response spectra of ground vibration. The delay interval chosen also affects fragmentation, primarily in massive rock, with an optimum relief between holes of 2 ms/ft. Strain gauge records indicate a possible mechanism consistent with this information. Research was done under contract H0222009 by Vibra-Tech Engineers, Inc. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–175858; paper copy price code A[illegible]. $22.95.

OFR 34–86. Dust Control Handbook for Longwall Mining Operations, by Glenn A. Shirey, Jay F. Colinet, and John A. Kost. May 1985. 223 pp. 56 figs. The objective of this contract was to prepare a detailed, readily usable handbook on dust control techniques for longwall mining operations. Information was gathered from available literature and through contacts with industry and government personnel. The handbook describes those methods of dust control applicable to today's longwall mining systems and contains sufficient design elements to assist operators with problems in testing or implementing new control procedures. Complete reference lists are presented at the end of each chapter to direct the reader to additional information. Research was done under contract J0348000 by BCR National Laboratory. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–178159; paper copy price code A11. $22.95.

OFR 35A–86. Underground High Volume Hydraulic Coal Mining. Volume I—Mid-Continent Resources, Inc., by R. G. Heers. June 1983. 141 pp. 19 figs. This report examines the technical and economic feasibility of hydraulically mining the 12- to 20-ft-thick Middle Bed coal seam at Mid-Continent Resources, Inc., near Carbondale, CO. The mining system permits the safe recovery of a seam that is too thick to be recovered by longwall methods. Dual rooms are developed straight up the 8° to 13° pitch. The bottom room, under top coal and supported by yieldable arches, serves as an intake and fluming room. The parallel room against the roof, supported by roof bolts, serves as a return air course and bleeder. The top coal and pillars are extracted by a jet of water directed by a monitor, eliminating the need for miners or machinery to work beyond a roof supported by yieldable arches. Pillar recovery and productivity are both improved over those of other systems. At the same time, safety is markedly enhanced by roof control with yieldable arches, remote control extraction of the top coal and pillars, elimination of electricity from the vicinity of the working face, and positive ventilation of the area being pillared. The study shows that it is highly feasible to produce 1.2 MMtpy clean coal by hydraulic mining with internal rates of return from 23% to 92%, based on a range of selling prices from $30 to $40 per ton and on the extent to which existing capital for shared facilities is charged against the hydraulic mine. Capital expenditures required for the hydraulic mine, including interest during construction, are estimated to be $18 million, and overall productivity is estimated to be 28 clean tons of coal per employee per shift. Research was done under contract J0233911 by B. C. Coal, Ltd., and R. G. Heers & Associates. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 35B–86. Underground High Volume Hydraulic Coal Mining. Volume II—Price River Coal Company Castlegate Mine, by R. G. Heers. June 1983. 152 pp. 29 figs. This report examines the technical and economic feasibility of hydraulically mining a 12- to 25-ft-thick coal lens in the A bed on the west side of Price River Coal Co. property in Carbon County, UT. Although the coal is hard and strong and pitches only 7° to 8°, hydraulic mining at a rate of 1,154,000 tpy was determined to be highly feasible using an induced caving system, using strata and abutment pressures in a controlled manner in causing coal breaking in the retreat mining faces. The coal would be developed by continuous miners in widely spaced dual rooms driven up the full pitch. About 83% of the production would be extracted from pillars and top coal by hydraulic monitors in the rooms, supported by yieldable aluminum arches. In the average seam thickness of 20 ft, it was estimated that the tonnage mined from arched headings would constitute only 3.4% of the total. Estimated average monitor production was over 1,500 tons per shift. The coal would be dewatered underground. Safety would be enhanced by controlling the roof and ribs with lightweight arches, remote controlled extraction of pillars and top coal, reduction of airborne dust, and positive ventilation of pillar faces. Both mining recovery and productivity would be improved over any other system used for such thick seams. With a selling price range of $25 to $35 per ton, free on rail, the estimated rate of return on the incremental capital of about $25 million would be 17% to 41%. Overall productivity would be 29.1 clean tons of coal per employee-day. Research was done under contract J0233911 by B. C. Coal, Ltd., and R. G. Heers & Associates. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 35C–86. Underground High Volume Hydraulic Coal Mining. Volume III—The Pittsburg & Midway Coal Mining Co. Kemmerer Coal Mine, by R. G. Heers. Sept. 1983. 137 pp. 25 figs. Hydraulic mining of the three thickest seams at Pittsburg & Midway Coal Mining Co.'s property at Kemmerer, WY, is technically and economically feasible because of the great thickness of the seams (30 to 90 ft), the 20° pitch, the absence of gas, the self-supporting top coal, and the low ash and sulfur content. Access to the coal seams is by 11,000-ft twin rock tunnels, declining on a 21° grade to a central underground dewatering station where the plus 14-mesh coal is screened off and conveyed out. The minus 14-mesh coal and spent water is pumped to the surface for cleaning and clarification. About 4,000 hp of hydraulic energy is provided to each of the three monitors, one in each seam. This energy, together with an induced caving system, is expected to produce over 1,400 tons of raw coal per monitor shift. Only 3% of the coal mined comes from development, which is accomplished by roadheader-type machines. Capital costs are estimated at $88 million including interest during construction, for a production of 3 MMtpy. The internal rate of return ranges from 18% to 27%, based on sales prices from $21 to $26 per ton, free on rail. Overall productivity is estimated at 42 tons per employee shift, and recovery is estimated at 60%. Extensive measures are provided for the prevention, detection, and control of spontaneous combustion. Safety is further enhanced by reduction of dust and by remote controlled extraction of top coal and pillars. Recovery and productivity are improved over those of any other underground mining method for such thick seams. Research was done under contract J0233911 by B. C. Coal, Ltd., and R. G. Heers & Associates. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 35D–86. Underground High Volume Hydraulic Coal Mining. Volume IV—Kocher Coal Company Porter Tunnel Mine, by R. G. Heers. June 1983. 131 pp. 24 figs. This report examines the technical and economic feasibility of hydraulically mining anthracite veins at Kocher Coal Co.'s Porter Tunnel Mine, in Schuylkill County, PA. Results show that if a market for 1.156 MMtpy of clean coal at prices ranging from $40 to $50 per ton, free on rail, can be obtained, hydraulic mining would provide internal rates of return ranging from 11%

to 23%, respectively. Capital costs are estimated to be $73 million, including interest during construction. An underground station, constructed at the base of the reserves, would collect all of the natural ground water, process water, and production coal. The dewatered plus ½-mm coal would be conveyed out of the mine, with a dilute slurry of minus ½-mm coal and water pumped to the cleaning plant on the surface. Development headings, supported by roof bolt trusses, are advanced by drilling, blasting, and flushing out the broken coal. To aid extraction by the high-pressure water jet, the pillars between sublevels are sized to partially crush under abutment pressure. Extraction of the pillars by jet eliminates the need for miners or machinery to work beyond a well-supported roof. Both pillar recovery and productivity are expected to be superior to those of other systems. At the same time, safety is markedly enhanced by improved roof control, remote control extraction of top coal and pillars, and elimination of dust. The productivity is estimated at 11.8 tons of clean coal per employee-day. Research was done under contract J0233911 by B. C. Coal, Ltd., and R. G. Heers & Associates. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 35E–86. Underground High Volume Hydraulic Coal Mining. Volume V—Frederic A. Potts & Co., Inc., by R. G. Heers. Sept. 1983. 137 pp. 26 figs. This report examines the technical and economic feasibility of hydraulically mining anthracite veins in Schuylkill County, PA. The Lykens Valley veins are 6.5 and 15 ft thick and dip 40° to 50°. This plan proposes a combination of induced caving and hydraulic monitoring. All development entries will be driven in rock by a tunnel boring machine. Parallel main levels will be developed on 250-ft centers in the hanging wall of each vein. The hydraulic monitor will extract the coal from drawpoints on 160-ft centers. Coal will be flumed to an underground dewatering station where the plus ½-mm coal will be dewatered and transported by conveyor to the preparation plan on the surface. The minus ½-mm coal and water, including the assumed 8,000 gpm of mine water inflow, will be pumped to the surface by plunger pumps. Miners and material transport will be provided by a suspended monorail system. One monitor will be operated, producing 883,000 clean tons per year. Productivity is estimated at 13.2 clean tons per employee-day. capital expenditures of $62 million, including interest during construction, are planned. At assumed selling prices of $40 to $50 per ton, free on rail, the discounted rate of return is 16% to 25%. Research was done under contract J0233911 by B. C. Coal, Ltd., and R. G. Heers & Associates. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 35F–86. Underground High Volume Hydraulic Coal Mining—Summary, by R. G. Heers. June 1983. 39 pp. This report is a summary of five sites, three bituminous and two anthracite, where hydraulic mining might be technically and economically feasible. The bituminous sites were the Mid-Continent Resources, Inc., mine near Carbondale, CO; the Price River Coal Co. Castlegate Mine near Helper, UT; and the Pittsburg & Midway Coal Mining Co. Kemmerer Coal Mine at Kemmerer, WY. The anthracite sites were the Kocher Coal Co. Porter Tunnel Mine and the Frederic A. Potts & Co., Inc., property, both located in Schuylkill County, PA. This volume contains a summary of each of the other five volumes and general remarks. The other volumes provide details about each site: a geological description of the reserves, the anticipated mining conditions, an estimate of the quantity of the reserves, the development and extraction method and necessary equipment, water system description, personnel requirements, estimated capital and operating costs, cash flow and rates of return for various selling prices, and environmental and socioeconomic considerations. Research was done under contract J0233911 by B. C. Coal, Ltd., and R. G. Heers & Associates. Available for reference at ALRC, AVRC, DRC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 37–86. Control of Respirable Quartz on Continuous Mining Sections, by Eric G. Kok, Roger F. J. Adam, and Robert A. Pimentel. Nov. 1985. 169 pp. 19 figs. Complying with reduced dust standards (that is, less than 2.0 mg/m^3) owing to quartz levels that exceed 5% is presently a critical problem for many continuous mining sections. Results are presented of research that was performed to determine the factors causing high levels of respirable quartz dust and to identify the major contributors to operator exposure. The significant sources of quartz dust are the drilling of the roof and the mining of the roof, floor, and rock bands. Both the miner and the bolter may be on a reduced standard, but compliance is easiest to achieve on the bolter, for which improvements in maintenance and operator practices are usually sufficient. At the miner, the problem is more elusive. Dust was produced not only by the cutting action but also by scooping, gathering, and loading operations. Research was completed to identify dust problem areas at the continuous miner. An analysis of the potential for research in a number of dust control research project areas is also presented. The research areas address the respirable quartz dust problem at continuous miners. Research was done under contract J0338078 by Ketron, Inc. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 5–86. Mineral Resources of the South Fork Owyhee River Study Areas, Owyhee County, Idaho, and Elko County, Nevada, by Ronald T. Mayerle and Peter N. Gabby. 1986. 15 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 24–86. Mineral Resources of the Roberts Wilderness Study Area, Eureka County, Nevada, by David A. Benjamin and Frederick L. Johnson. 1986. 27 pp. 10 figs. Western Field Operations Center, Spokane, WA.

MLA 25–86. Mineral Resources of the Park Range Wilderness Study Area, Nye County, Nevada, by Frederick L. Johnson and David A. Benjamin. 1986. 13 pp. 5 figs. Western Field Operations Center, Spokane, WA.

MLA 27–86. Mineral Resources of the Whitewater Study Area, Riverside and San Bernardino Counties, California, by Edward L. McHugh. 1986. 16 pp. 3 figs. Western Field Operations Center, Spokane, WA.

MLA 28–86. Mineral Investigation of the Sabinoso Wilderness Study Area (NM–010–055), San Miguel County, New Mexico, by Carl L. Almquist. 1986. 11 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MLA 29–86. Mineral Resources of a Part of the Mount Grafton Wilderness Study Area (NV–040–169), Lincoln and White Pine Counties, Nevada, by Mark L. Chatman. 1986. 77 pp. 14 figs. Intermountain Field Operations Center, Denver, CO.

MLA 30–86. Mineral Resources of the Honeycombs Study Area, Malheur County, Oregon, by Douglas F. Scott. 1986. 26 pp. 4 figs. Western Field Operations Center, Spokane, WA.

MLA 32–86. Mineral Resources of the Little Blitzen Gorge Study Area, Harney County, Oregon, by Thomas J. Peters and Leon E. Esparza. 1986. 14 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 33–86. Mineral Resources of the Blue Lakes and Alder Creek Wilderness Study Areas, Humboldt County, Nevada, by Spencee L. Willett. 1986. 21 pp. 3 figs. Western Field Operations Center, Spokane, WA.

MLA 34–86. Mineral Investigation of a Part of the Paria-Hackberry Wilderness Study Area (UT–040–247), Kane County, Utah, by S. Don Brown and Brian J. Hannigan. 1986. 25 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

MLA 35–86. Mineral Resources of the Mt. Limbo Wilderness Study Area and Vicinity, Pershing County, Nevada, by Clayton M. Rumsey. 1986. 11 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 38–86. Mineral Investigation of a Part of the Rio Chama Wilderness Study Area (NM–010–059), Rio Arriba County, New Mexico, by Russell A. Schreiner. 1986. 10 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

IV. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 41–86. Heat Capacity of Cadmium Oxysulfate From 5.16 to 300.7 K and Relative Enthalpy to 1001.5 K, by R. P. Beyer and M. J. Ferrante. J. Chem. Thermodyn., v. 18, 1986, pp. 365–370. The heat capacity of cadmium oxysulfate ($2CdO \cdot CdSO_4$) from 5.16 to 300.7 K was measured by adiabatic calorimetry and the relative enthalpy to 1001.5 K by copper-block drop calorimetry. A nonisothermal transition was observed over the temperature range 245 to 260 K with a peak at 253 K. The values at 298.15 K for $C^\circ_{p,m}$, $\{S^\circ_m(T) - S^\circ_m(0)\}$, $-\{G^\circ_m(T) - H^\circ_m(0)\}/T$, and $\{H^\circ_m(T) - H^\circ_m(0)\}$ are 193.67, 246.59, and 125.81 $J \cdot K^{-1} \cdot mol^{-1}$, and 36.01 $kJ \cdot mol^{-1}$, respectively. These properties are also reported at convenient temperature intervals from 5 to 1000 K.

OP 42–86. Relative Importance of Abrasion and Corrosion in Metal Loss in Ball Milling, by J. Dodd, D. J. Dunn, J. L. Huiatt, and T. E. Norman. Miner. and Metall. Process., v. 2, No. 4, Nov. 1985, pp. 212–216. Corrosion studies in laboratory ball mills and grinding environment simulations produce corrosion rates and total metal removal rates much lower than those recorded in operating production ball mills. The corrosion component of ball metal loss in many mills probably represents less than 10% of the total loss, judging from AMAX Inc. experience and recent U.S. Bureau of Mines tests. Such small absolute losses are consistent with ball metal loss measured in production ball mill marked ball wear tests to determine effects of corrosion and abrasion resisting properties of alloys in operating mills. These indicate that metal hardness and microstructure determine relative metal loss rates of a given situation. The combination of ore characteristics and grinding process dynamics determine metal loss severity. Alloying for corrosion resistance and modification of the milling corrosion environment yield relatively small metal loss reductions. Alloying and heat treatment to produce high hardness and microstructures of high carbon martensite and, for cast irons M_7C_3 carbides, produce the lowest metal losses in typical wet grinding applications.

OP 43–86. Characterization and Measurement of Longwall Rock Mass Movement, by Jeffrey M. Listak, John L. Hill III, and Joseph C. Zelanko. Ch. 14 in Rock Characterization Techniques (Proc. SME-AIME Annu. Meeting, New Orleans, LA, Mar. 3–6, 1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 133–141. This paper addresses the origins, directions, and magnitudes of loads imposed on longwall roof supports by the caving of the overlying strata. Physical property data are also presented to demonstrate the relationship between caving behavior and local geology. Analyses of data show that strata behavior above longwall extractions is highly dependent upon lithology with major disturbances occurring at weak zones. Information collected from this study is correlated with measurements taken from several other studies (i.e., shield support load measurements, pillar loading, and subsidence measurements) to provide a comprehensive description of the stress distribution and strata behavior associated with the extraction of a longwall panel.

OP 44–86. Anaerobic Extraction of Cobalt in a Pulse Column, by Larry R. Penner, Richard E. Siemens, and Gloria J. Galvan. Solvent Extr. and Ion Exch., v. 4, No. 2, Apr. 1986, pp. 345–360. The effects of excluding air (oxygen) from a cobalt solvent extraction circuit were studied for LIX 64N extractant. After solvent extraction of divalent cobalt from ammoniacal solutions with chelating extractants such as LIX 64N, the loaded Co-chelate is believed to oxidize to a stable trivalent complex that resists subsequent stripping with mineral acids. To improve stripping efficiency, cobalt was extracted and stripped in the absence of oxygen in pulsed, perforated-plate columns that were designed and constructed by the Bureau of Mines. When the ammoniacal cobalt(II) sulfate and LIX 64N solutions were purged, blanketed, and pulsed with argon, cobalt extraction exceeded 99%, and stripping with 1 vol % H_2SO_4 reached 98.5%. The stripped extractant was recycled to the extraction column with no loss of extraction efficiency in six passes through the circuit.

OP 45–86. Options in the HCl Process for the Production of Alumina From Clay, by D. E. Shanks, D. C. Thompson, R. M. Arington, G. L. Dan, and J. A. Eisele. Paper in Light Metals 1986, ed. by R. E. Miller. Metall. Soc. AIME, Warrendale, PA, 1986, pp. 25–33. The Bureau of Mines has conducted in-depth studies on the recovery of aluminum chloride hexahydrate and alumina from domestic kaolinitic clay. The original goal of the studies was to provide the technology for alumina production from domestic raw materials. Current research is focused on process modifications that would improve the economics of clay-HCl leaching and improve chances for transfer of the technology to commercial use. Options under investigation include direct leaching of raw clay, changes in leaching acid concentration and stoichiometry, decreased leaching duration, improved solid-liquid separations, elimination of solvent extraction for iron removal, and formation of basic aluminum chloride instead of aluminum chloride hexahydrate as an intermediate product. Implementation could decrease energy, equipment, and reagent costs by eliminating the calcination step, substituting filtration for thickening and washing circuits, and combining iron removal with aluminum chloride crystallization.

OP 46–86. Subsolidus Compatibility in the System NaCl-KCl-$AlCl_3$-NaF-KF-AlF_3, by Charles A. Sorrell and John G. Groetsch, Jr. J. Am. Ceram. Soc., v. 69, No. 4, Apr. 1986, pp. 333–338. The chemistry and properties of salts used as fluxes for recycling aluminum were studied. Many fluxing salts fall within the system NaCl-KCl-$AlCl_3$-NaF-KF-AlF_3, which has been shown to be a reciprocal system, with NaF-KCl, KCl-AlF_3, and NaCl-AlF_3 as the stable mixed-halide binaries. Twelve subsolidus compatibility tetrahedra were determined by X-ray analyses of samples heated in evacuated sealed tubes. X-ray measurements of quenched and annealed samples indicate that elpasolite, nominally K_2NaAlF_6, has a compositional range between 60 mol % Na_3AlF_6, 40 mol % K_3AlF_6 and 25 mol % Na_3Alf_6, 75 mol % K_3AlF_6. Improved X-ray powder data are given for $KAlF_4$, showing a previously reported structure to be essentially correct.

OP 47–86. The Flotation of Sulfide Minerals—Electrochemical Aspects, by R. Woods and P. E. Richardson. Ch. 9 in Advances in Mineral Processing—A Half-Century of Progress in Application of Theory to Practice, ed. by P. Somasundaran. Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 154–170. Selectivity in sulfide flotation arises from the nature of the interaction between collector species and the mineral surface.

This takes place by a mixed potential mechanism involving separate electrochemical steps. The process that leads to a hydrophobic mineral surface is an anodic oxidation reaction that fixes the collector at the interface, and this is balanced by the cathodic reduction of oxygen. Studies carried out using solid and particulate bed electrodes have identified the hydrophobic entity as a chemisorbed species, a metal-thiol compound, or a dithiolate, depending upon the collector, the mineral, and the solution composition. Recovery potential relationships have been determined for a number of single mineral systems, and the results correlate with electrochemical studies at electrodes. Studies on mineral mixtures have shown that the recovery is influenced by other components. Depressant action generally takes place by lowering the mixed potential below the flotation edge for the mineral. Self-induced flotation is also a function of potential.

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MINERAL PERSPECTIVE

MP. Mineral Industries of the Middle East, by Staff, Branch of Africa and the Middle East, Division of International Minerals. 1986. 65 pp. 32 figs. This Bureau of Mines report presents a summary of the mineral industries of the 16 countries in the Middle East. Countries in this region differ widely, from those heavily endowed with hydrocarbon resources but with limited nonfuel resources, such as Saudi Arabia, Kuwait, and Qatar, to those heavily mineralized countries with limited petroleum reserves, such as Turkey, and to those with little mineral activity of any kind, such as Lebanon. Base maps and tables show the location and salient features of each country's mineral and petroleum industries. The text highlights the important aspects of mineral supply and trade, mineral policy, industry structure, labor, energy, and the outlook for future developments in the industry. Infrastructure of importance to the mineral industry of each country, including railways, roads, and pipelines, is included on each map. Photographs of some operations are included. GPO Stock No. 024–004–02161–6. $3.50.

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REPORTS OF INVESTIGATIONS

RI 9011. Corrosion Resistance of Selected Ceramic Materials to Sulfuric Acid, by James P. Bennett. 1986. 11 pp. 3 figs. The Bureau of Mines is investigating the acid resistance of ceramic materials to identify construction materials for emerging technology in chemical and metallurgical processes. Eight commercial ceramic materials were evaluated: two red shale, two fireclay, one silicon carbide, one silica, one carbon, and one high-alumina. Samples were exposed to 10 wt pct H_2SO_4 at 50° C and 10, 30, 50, 70, and 90 wt pct H_2SO_4 at 90° C for time periods of 110 days. Statistically significant changes in cold crushing strength were observed in the silicon carbide and carbon materials. Weight changes and the leach rate of Al, Ca, Fe, K, Mg, Na, Si, and Ti were also monitored. The most severe corrosion conditions were at 90° C and 30 to 50 wt pct H_2SO_4 for the acidproof and at 10 wt pct H_2SO_4 for the acid-resistant materials. The silica and the high-alumina materials were the most acid-resistant, followed by the higher density red shale and fire clay. This report is based upon work done under an agreement between the University of Alabama and the Bureau of Mines.

RI 9012. High-Purity, Fine-Particle Boron Nitride Powder Synthesis at -75° to 750° C, by Rustu S. Kalyoncu. 1986. 9 pp. 3 figs. Nonoxide ceramics with improved high-temperature properties could substitute for nigh-temperature alloys and reduce the Nation's dependence on imports of Cr, Co, Ni, and Mn. To meet this objective, the Bureau of Mines conducted research to synthesize ultrafine reactive boron nitride (BN) powders. BN powders were prepared at temperatures ranging from -75° to 750° C. Low-temperature reactions (-75° to 200° C) between boron halides and N compounds led to formation of elemento-organic compounds that were thermally decomposed to ultrafine (approximately 100- to 150-Å particle size) reactive BN powders. BN powders were also prepared through the reaction of a low-melting inorganic B compound (boric acid, borax) with an organic N compound (carbimide and thiocarbimide) in N_2 and/or ammonia (NH_3) atmospheres at temperatures between 500° and 750° C. This report is based upon work done under an agreement between the University of Alabama and the Bureau of Mines.

RI 9013. Comparisons Between Cross-Measure Boreholes and Surface Gob Holes, by T. W. Goodman and J. Cervik. 1986. 14 pp. 21 figs. The Bureau of Mines conducted studies to compare the effectiveness of the cross-measure borehole system with that of surface gob holes on two successively mined retreating longwalls in the Lower Kittanning Coalbed. Only the cross-measure system was in operation on panel A; on panel B, both systems were in operation. In addition, the cross-measure boreholes on panel B were drilled parallel to the face, whereas those on panel A were drilled at a 45° angle with respect to the longwall axis. The studies show that the cross-measure system captured 71 pct of the methane generated by longwall mining on panel A. On panel B, the surface gob hole dominated over the cross-measure system for about 700 ft (213 m) after it was intercepted. Beyond that point, the cross-measure system dominated. About 93 pct of the methane generated on panel B was captured by the two systems. Cross-measure boreholes that were drilled parallel to the face were as effective as boreholes oriented 45° with respect to the longwall axis. In addition, they were shorter and required less drilling time. Comparison between observed gas pressure differentials in boreholes and calculated values indicate that boreholes can be shortened further to 140 ft (43 m). Additional studies are needed to verify these calculations.

RI 9014. Seasonal Variation in Respirable Dust Concentration in U.S. Coal Mines, by Nevin Greninger, Welby Courtney, and Edward Divers. 1986. 7 pp. 4 figs. The Bureau of

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Mines examined the possibility of a seasonal variation of respirable dust concentration in U.S. coal mines. The first step was to review company and MSHA-inspector dust samples that had been collected during the past several years in 14 selected mines for compliance purposes. Results indicated severe scatter in data; most standard deviations of the dust concentrations measured in winter and summer months were comparable in magnitude with the mean values of dust concentrations for the seasons. Therefore, a detailed statistical analysis was conducted. At the 90% confidence level, the company samples of three mines had winter means 0.15 to 0.54 mg/m^3 higher than the summer means; six mines had negligible seasonal variations; and five mines had winter means that ranged from higher to lower than the summer means. Inspector data, however, were too sparse for analysis. In view of both the low frequency of occurrence of a seasonal effect and its wide scatter in several of the mines, the study was ended with the conclusion that seasonal variation in respirable dust levels, in general, is an insignificant factor.

PREPRINTS FROM MINERALS YEARBOOK, 1984

These preprints are chapters from Minerals Yearbook, 1984. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

The Mineral Industry of Alaska, by Tom L. Pittman. 16 pp. 2 figs.
The Mineral Industry of Arizona, by Lorraine B. Burgin. 21 pp. 2 figs.
The Mineral Industry of California, by F. V. Carrillo, J. F. Davis, and M. A. Silva. 13 pp. 2 figs.
The Mineral Industry of Colorado, by Karl E. Starch and Patricia La Tour. 18 pp. 2 figs.
The Mineral Industry of Florida, by James R. Boyle and Charles W. Hendry, Jr. 15 pp. 2 figs.
The Mineral Industry of Georgia, by Doss H. White, Jr., and Bruce J. O'Connor. 16 pp. 2 figs.
The Mineral Industry of Kentucky, by Donald K. Harrison and Garland R. Dever, Jr. 12 pp. 2 figs.
The Mineral Industry of Louisiana, by James R. Boyle and Charles G. Groat. 11 pp. 2 figs.
The Mineral Industry of Maryland, by William A. Bonin. 10 pp. 1 fig.
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The Mineral Industry of Wyoming, by Karl E. Starch and Gary B. Glass. 11 pp. 2 figs.

III. Open File Reports—NTIS

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RERC	**Reno Research Center, USBM, Reno, NV.**
RORC	**Rolla Research Center, USBM, Rolla, MO.**
SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 36–86. Investigation and Control of Noise Generated During Coal Cutting, by Mark R. Pettitt. Aug. 1985. 138 pp. 70 figs. This report presents the results of an extensive research and development program to reduce the noise generated during coal cutting. The characteristics and magnitude of continuous miner coal cutting noise sources are defined. This work consisted of development of a simulated coal seam to facilitate aboveground coal cutting tests, noise measurements in a reverberant acoustic chamber during simulated mining operations of a continuous miner (cutting the simulated coal seam), and noise measurements in an underground coal mine during continuous miner operation. In-mine and laboratory test results were in excellent agreement for both A-weighted overall levels as well as A-weighted one-third octave band spectra. Methods to reduce coal cutting noise are presented. These methods take full advantage of the dynamic characteristics of the forces generated during coal cutting. Dynamic cutting force isolation was shown to be a very effective technique. Finally, a continuous miner was equipped with a cutter head that incorporated (among other design factors) cutting force isolation. Successful long-term, in-mine use of the cutter head demonstrated coal cutting noise at the operator's station of less than 90 dBA and 50% coal, 50% rock cutting of less than 93 dBA. Research was done under contract J0387229 by Wyle Laboratories. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–189008; paper copy price code A07. $16.95.

OFR 38–86. On the Development of a Model-Based Control Strategy for Copper-Ore Flotation, by J. A. Herbst, R. Zaragoza, and O. A. Bascur. Feb. 1986. 70 pp. 13 figs. During the last decade, it has been established that conventional flotation control strategies based on classical control theory result in significant increases in grade, recovery, and operating cost savings. In the current report, description of an advanced model-based control philosophy is presented. The derivation and verification of a simplified flotation model is described. The implementation of a Kalman filter for estimation of unmeasured variables for input to controllers is discussed. Several control strategies using the model-based approach are described, emphasizing the nonlinear nature of the flotation plant. Expected trends in the implementation of such model-based flotation control strategies in the future are discussed. Research was done under contract J0215035 at the University of Utah. Available for reference at AD/MMR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–190170; paper copy price code A04. $11.95.

OFR 39–86. Application of Mathematical Modeling to the Analysis of Ground Water Flow Patterns Near a Deep Underground Mine, by Paul Frankel. Jan. 1986. 85 pp. 25 figs. The purpose of this study was to evaluate the relative importance that several major geologic structural features have on ground water potential distribution and their impact on abandonment practices of deep underground mines. The U.S.G.S. Modular Finite Difference Ground Water Flow Model was utilized in analyzing conditions at the Bunker Hill Mine near Kellogg, ID. Observations suggested that ground water flow near the Bunker Hill Mine is controlled by secondary hydraulic conductivity created by the existing structural features. The research suggests several ways to reduce inflow to mines through fault zones. Research was done under grant G1125132–1651 at the University of Idaho. Available for reference at AD/MR and LIB. Copies of this report will not be available for purchase.

OFR 40–86. The Electrowinning of Dilute Zinc Sulfate Solutions in a Fluidized Bed Electrochemical Reactor, by Richard Z. Squillace. Nov. 1985. 69 pp. 16 figs. A cylindrical, fluidized bed electrochemical reactor (FBER) was employed to electrowin dilute zinc sulfate solutions containing 2.5 to 15 g/L zinc. The planar electrodes used in the industrial electrowinning of zinc requires 50 to 65 g/L zinc. A low acid catholyte solution of 5 g/L is the maximum concentration necessary for the efficient recovery of zinc. The addition of 60 g/L of Na_2SO_4 electrolyte improved both the catholyte conductivity and current efficiency. The optimum current efficiency and current density were obtained using a particle size of plus 355 minus 500 μm and a bed width of 1.3 cm. At a zinc concentration of 15 g/L, the FBER could be operated at current densities and at volumetric reaction rates greatly exceeding that of a conventional planar electrowinning cell. Research was done under grant G1125132–1902 at the University of Nevada at Reno. Available for reference at AD/MMR, LIB, and RERC. Copies of this report will not be available for purchase.

OFR 41–86. Measurement and Construction of Dust Distribution Maps for Longwall Faces, by S. S. Peng and H. S. Chiang. Jan. 1986. 110 pp. 45 figs. This report describes the development of dust distribution maps to aid in the prevention of the production and spread of airborne dust. Air velocity and flow patterns were measured by velometers and smoke tubes positioned at the 3d or 5th support from the head entry T-junction, at the 11th and every 10th support thereafter, with the last station located at the tail entry T-junction. Moving and fixed real-time aerosol monitor surveys also measured respirable dust both near the shearer and the support advance. Airflow distribution along the longwall face differed among the five mines surveyed as well as from face to face within the same mine. The most important contributing factor seemed to be the air leakage conditions in the gob. Location of high dust concentrations are identified and the techniques to control them are discussed. Research was done under grant G1135142–5403 at West Virginia University. Available for reference at AD/MR, LIB, MSHA, PRC/B, and TCRC. Copies of this report will not be available for purchase.

OFR 51–86. Lode Platinum-Group Metals Potential of the Goodnews Bay Ultramafic Complex, Alaska, by D. D. Southworth and Jeffrey Y. Foley. Apr. 1986. 87 pp. 22 figs. In 1981, 1982, and 1983, the Bureau of Mines examined the potential for lode deposits of platinum-group metals (PGM) in the Goodnews Bay ultramafic complex, Alaska. The complex consists of the Red Mountain, Suzie Mountain, and Smalls River ultramafic bodies and displays concentric zoning of rock types similar to complexes in southeast Alaska, British Columbia, and the Ural Mountains in the U.S.S.R. Results of the study indicate that platinum is preferentially associated with chromite and magnetite in the dunite core of the complex, and palladium is preferentially associated with sulfide minerals in the outer clinopyroxene-rich zones. The most promising targets for PGM lode deposits are the chromite-rich dunite at the heads of Fox Gulch and Squirrel Creek and the iron-nickel and iron-copper sulfide-bearing magnetite clinopyroxenite and hornblende-rich rocks outward of the dunite core, also found in the Fox Gulch-Squirrel Creek area. Significant placer reserves are present in the unmined, deeply buried placer ground in the lower Salmon River Valley and also in tailings from previous dredging. Research was done at the Bureau of Mines Alaska Field Operations Center. Available for reference at AD/MDA, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Copies of this report will not be available for purchase.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 36–86. Mineral Resources of the Kingston Range Study Area, San Bernardino County, California, by Arel B. McMahan and Clayton M. Rumsey. 1986. 27 pp. 8 figs. Western Field Operations Center, Spokane, WA.

MLA 39–86. Mineral Investigation of a Part of the Horse Mountain Wilderness Study Area (NM–020–

043), Catron County, New Mexico, by Carl L. Almquist. 1986. 9 pp. 1 fig. Intermountain Field Operations Center, Denver, CO.

MLA 41–86. Mineral Resources of a Part of the Ignacio Chavez Wilderness Study Area (NM–010–020), McKinley and Sandoval Counties, New Mexico, by Russell A. Schreiner. 1986. 11 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

MLA 42–86. Mineral Investigation of a Part of the Little Black Peak (NM–060–109)/Carrizozo Lava Flow (NM–060–110A) Wilderness Study Area, Lincoln County, New Mexico, by Jeanne E. Zelten. 1986. 21 pp. 5 figs. Intermountain Field Operations Center, Denver, CO.

MLA 43–86. Mineral Investigation of a Part of the Canaan Mountain Wilderness Study Area, Kane and Washington Counties, Utah (UT–040–143) and Mohave County, Arizona (AZ–010–041), by Terry J. Kreidler. 1986. 13 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

IV. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 48–86. Acid Brick and Silica Brick, by James P. Bennett and William M. Eckert. Ch. 15 in Corrosion and Chemical Resistant Masonry Materials Handbook, ed. by Walter Lee Sheppard, Jr. Noyes Publ., Park Ridge, NJ, 1986, pp. 144–154. Physical properties, chemical resistance, temperature restrictions, volume expansion, and applications of acid brick (red shale and fireclay) and silica brick are contrasted. Tables and charts presenting the results of exposing both types of material to select acids are included.

OP 49–86. The Effect of Oxygen on the Open-Circuit Passivity of Fe–18Cr, by B. S. Covino, Jr., M. Rosen, T. J. Driscoll, T. C. Murphy, and C. R. Molock. Corros. Sci., v. 26, No. 2, Feb. 1986, pp. 95–107. Electrochemical studies were conducted to determine the critical amount of oxygen necessary to prevent corrosion by maintaining the open-circuit passivity of Fe–18Cr samples initially passivated at 0.6 V normal hydrogen electrode (NHE) in 1*N* H_2SO_4 solutions. Samples passivated at 0.6 V(NHE) and then released to open circuit in O_2-saturated (29.4 ppm O_2 dissolved) solution maintained a state of passivity. Samples passivated and released to open circuit in N_2-purged solution decayed to a state of active corrosion in 800 to 2,000 min. A passive state, however, could be maintained if O_2 were added to the N_2 flow so that a minimum of 1.7 ppm O_2 was present in solution. Furthermore, this critical amount of O_2 had to be added before open-circuit decay reached 0.45 V(NHE). Auger electron spectroscopy measurements indicated that following open-circuit stabilization of passivity by O_2 the percentage chromium in the film increased with increasing open-circuit potential. X-ray photoelectron spectroscopy measurements indicated that the film thickness decreased with increasing open-circuit potential.

OP 50–86. Dewatering of Red Mud, by G. D. Hood, G. M. Wilemon, D. A. Stanley, and B. J. Scheiner. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 655–664. A solid-liquid separation technique devised by the Bureau of Mines, U.S. Department of the Interior, was applied to red mud, the caustic-containing residue generated when alumina is extracted from bauxite by the Bayer process. Red mud obtained from Jamaican bauxite was dewatered in laboratory batch tests and small-scale continuous tests to develop an inexpensive method of washing the mud and recovering the valuable sodium aluminate and caustic. A number of high-molecular-weight polymers were evaluated, and a high-anionic powder polymer used in combination with a high-anionic, emulsion-type polymer proved to be most effective. In small-scale continuous tests using a baffled tube mixer to aid floc formation and a rotating trommel to dewater the solids, slurries with an initial concentration of 10 pct solids were dewatered to 27 pct solids using 0.20 kg of polymer per ton of dry solids. After the trommel treatment, the flocculated red mud was placed in a column fitted with a screen to allow released water to drain; after 15 days, the solids content increased over 40 pct.

OP 51–86. High-Purity, Fine Ceramic Powders Produced in the Bureau of Mines Turbomill, by Jesse L. Hoyer and Arthur V. Petty, Jr. Ceram. Eng. and Sci. Proc., v. 6, No. 9–10, Sept.–Oct. 1985, pp. 1342–1355. The Bureau of Mines turbomill is being evaluated for the production of ultrafine, high-purity, ceramic powders. Such highly reactive ceramic powders could contribute to improve performance of structural materials fabricated for use in severe conditions of temperature, pressure, and environment. The materials studied were alpha-silicon carbide (α-SiC), silicon nitride (Si_3N_4), titanium diboride (TiB_2), quartz (SiO_2), alumina (Al_2O_3), and zirconia (ZrO_2). The agglomeration characteristics of α-SiC and the effects of dispersing agents on agglomeration were also evaluated. Ultrafine α-SiC powders with an average diameter of 1.31 μm (51 pct <1 μm) were produced in 1 h in the Bureau's all-polymer turbomill. A sodium lignosulfonate was found to be the best dispersant for SiC powders, resulting in the least agglomeration and in negligible contamination from the milling process. Si_3N_4 powders were prepared from two different starting materials, each with a diameter of 55 μm. Milled powders had average particle sizes of 2.96 μm (20 pct <1 μm) after 1 h in the one case, and 2.09 μm (51 pct <1 μm) after 2 h in the other. TiB_2, with an average initial diameter of 35 μm, was reduced to 5.52 μm (2 pct <1 μm) in 1 h. SiO_2, ZrO_2, and Al_2O_3 (starting materials with average diameters of 30.52, 20.11, and 101.74 μm) were ground to 3.44 μm (12 pct <1 μm), 3.09 μm (15 pct <1 μm), and 2.69 μm (28 pct <1 μm), respectively, in 1 h. Contamination of the powders produced in the turbomill was negligible, which is advantageous for high-temperature applications where purity is a primary concern.

OP 52–86. BN Powder Synthesis at Low Temperature, by Rustu S. Kalyoncu. Ceram. Eng. and Sci. Proc., v. 6, No. 9–10, Sept.–Oct. 1985, pp. 1356–1364. The Bureau of Mines has devised a laboratory technique for preparing ultrafine boron nitride (BN) powders through the formation of elemento-organic BN precursor compounds at low temperatures. Structural materials produced from such highly reactive powders may have applications in the severe conditions of temperature, pressure, and environment encountered in mining and mineral processing. The reactions of sodium borohydride ($NaBH_4$) with ammonium chloride (NH_4Cl) in an organic solvent such as chlorobenzene, ammonia (NH_3) with boron trichloride (BCl_3), and NH_4Cl with BCl_3 were studied at temperatures ranging from –75° to 200° C. All three reaction systems resulted in the formation of precursor compounds, the carbothermic decomposition of which yielded ultrafine amorphous BN powders.

OP 53–86. The Feasibility of Using Stereoscopic Photography To Improve Miners' Training on Groundfall Hazards, by Robert H. Peters. Paper in the Proceedings of the Fourth Annual Meeting of the Collegiate Association for Mining Education. Univ. MO-Rolla, Oct. 3, 1985, pp. 2–17. This paper describes Bureau of Mines research to determine the feasibility of using stereoscopic slides to improve miners' ability to recognize dangerous roof and rib conditions. In comparison to conventional slides, stereoscopic slides give the viewer a better perception of certain details such as the presence of cracks and gaps in the roof rock. Data were collected from mine safety and training personnel using structured interview guides and stereoscopic slides. The overwhelming majority of those interviewed indicated that stereoscopic slides are far superior to conventional slides for portraying groundfall hazards, and that their use as a training aid for underground coal miners is quite feasible.

OP 54–86. Formation of a Molybdenum Silicon Suboxide: Growth of SiO_2 Pegs, by James C. Rawers. J. Mater. Sci. Lett., v. 5, No. 5, May 1986, pp. 513–515. The high-temperature, long-term oxidation resistance of a low-chromium, silicon-molybdenum-iron alloy has been shown to result from the formation of a SiO_2 suboxide layer. This layer at the metal-oxide interface was observed by removing the substrate metal via chemical etching. Scanning electron micrographs of the oxide surface at the metal-oxide interface showed the presence of suboxide pegs extending into the substrate metal. A time sequence for the oxidation process of the alloy is presented.

OP 55–86. The Flocculation of Fine Particles With Polyethylene Oxide: A Proposed Mechanism, by B. J. Scheiner and D. A. Stanley. Soc. Min. Eng. AIME preprint 86–75, 1986, 10 pp. The Bureau of Mines has developed a system for dewatering waste slurries by flocculating mineral particles with polyethylene oxide (PEO) and dewatering the resulting flocs on static and/or rotary screens. This paper discusses data obtained from dewatering, rheology, and ion-exchange experiments. A possible mechanism is postulated for the attachment of PEO to claylike particles through a water bridge with the intershell waters of the exchanged ion and the polymer.

OP 56–86. Recycling Zircon From Investment Casting Molds, by C. W. Smith, T. O. Llewellyn, and G. V. Sullivan. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 665–674. The Bureau of Mines, U.S. Department of the Interior, conducted physical and chemical beneficiation studies on three samples of waste investment casting molds to develop a method to liberate and recover zircon. Rod-mill grinding, autogenous attrition grinding, and caustic leaching were the liberation methods investigated. Flotation, gravity separation, and caustic leaching and sizing were the recovery methods investigated. Flotation techniques produced concentrates containing up to 74.2 pct zircon with a zircon recovery of 53.4 pct. Gravity concentration produced concentrates containing up to 98.6 pct zircon; however, recovery of the zircon was only 57 pct. Caustic leaching and sizing produced concentrates containing up to 98 pct zircon with attendant recoveries of 81 pct.

OP 57–86. Water Spray Cooler for Cooling Hot Working Environments in Mines, by E. D. Thimons, J. F. McCoy, and J. R. Marks. Paper 14 in Proceedings of Frigair 86 Conference, Pretoria, Republic of South Africa, Apr. 14–18, 1986, v. 1, 6 pp. The need for more efficient mine refrigeration equipment is greater than ever, as increasing numbers of U.S. mines are being operated at greater depths in order to reach minable ore deposits. The combination of high temperatures and high humidities encountered at these depths make a comfortable working environment difficult and expensive to maintain. Many ore bodies mined today could not be mined without cooling of the underground environment. Miners' safety, comfort, and productivity all suffer if air refrigeration needs are not satisfied. The water spray coolers described in this report are efficient and economical devices for dealing with the heat problem encountered in deep mines. Four limited bulk water spray coolers were designed and built. The first of these coolers, a single-stage unit, was tested in the Mount Taylor Mine near Grants, NM, before it closed. The remaining three coolers, a two-stage cooler and two three-stage coolers, were installed in the Homestake Gold Mine in Lead, SD. To date, all the coolers have performed well under in-mine conditions and have required only minimal maintenance. This paper details the design and performance of these coolers.

OP 58–86. Lessons Learned From First Impulse Turbine Installation in the U.S. Mining Industry, by E. D. Thimons and R. N. Torbin. Paper 25 in Proceedings of Frigair 86 Conference, Pretoria, Republic of South Africa, Apr. 14–18, 1986, v. 1, 7 pp. The Bureau of Mines, as part of its Health and Safety Research Program, has investigated a technique for improving the performance of mine refrigeration systems. By converting the potential energy of the incoming water to electrical energy rather than to heat energy, the water stays colder. This results in cooler mine temperatures and a healthier, more comfortable working environment for miners. A primary spinoff advantage resulting from this research is an energy savings from employing such a refrigeration technique. Recognizing the value of recoverable potential energy, the Bureau of Mines has undertaken a project to study the application of energy recovery techniques to the U.S. mining industry. To this end, the Bureau has contracted with Foster-Miller, Inc., of Waltham, MA, to investigate, evaluate, and demonstrate commercially available means of efficiently recovering the energy from any incoming cooling water source. This project has led to procurement, installation, and operation of a complete thermal energy recovery system. The test site was the Lucky Friday Mine, owned and operated by the Hecla Mining Co. of Wallace, ID. The system has now been successfully operating for 20 months.

OP 59–86. Sulphur Hexafluoride as a Mine Ventilation Research Tool—Recent Field Applications, by Robert J. Timko and Edward D. Thimons. J. Mine Vent. Soc. S. Afr., v. 39, No. 2, Feb. 1986, pp. 13–20. Sulfur hexafluoride (SF_6) is an odorless, colorless, nontoxic gas that has found acceptance as a tracer gas in research on ventilation patterns, measurement of air leak rates, respirable dust reductions due to bagging hood modifications, and the study of airflows relating to gob boreholes. Following a short review of the SF_6 sampling technique, this report describes recent Bureau of Mines projects in which SF_6 was used successfully as a tracer gas, enabling researchers to acquire representative data quickly and inexpensively.

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REPORTS OF INVESTIGATIONS

RI 9015. A Short-Term Evaluation of Compressible Stoppings Used in Trona Mines, by R. J. Timko. 1986. 14 pp. 12 figs. In an attempt to reduce the damage to ventilation stoppings caused by strata convergence, many mines are now using new stopping construction techniques that include compressible materials. This Bureau of Mines study concentrated on compressible stoppings in use in underground trona mines, all of which had overburden in excess of 1,000 ft. This overburden depth, in conjunction with the relatively soft floor in trona mines, has commonly created excessive floor heave throughout mined-out entries. Five different compressible stopping assemblies were examined: metal, wood, a wood-polyisocyanurate hybrid, and "small" and "large" expanded polystyrene (EPS) blocks. Testing was done in both elliptical and rectangular openings, and both rigid urethane foam (RUF) and a mortar-based sealant were used in different tests—for sealing either the perimeter (and joints) or the entire stopping face. Results showed that the EPS stoppings sealed with RUF were superior in prevention of air leakage in the mine openings evaluated. EPS has the advantage of being capable of being cut to any size and shape required. The mortar-based sealant was susceptible to degradation, especially around perimeter interfaces with the mineral surface, because of the hygroscopic nature of trona.

RI 9016. Large-Scale Dewatering of Phosphatic Clay Waste From Polk County, FL, by D. R. Brooks, B. J. Scheiner, A. G. Smelley, and J. R. Boyle, Jr. 1986. 8 pp. 4 figs. The Bureau of Mines has tested a dewatering technique for phosphatic clay waste. The technique utilizes a flocculant, polyethylene oxide (PEO), that forms strong, stable flocs that can be dewatered on a static screen followed by further dewatering on a rotary screen or trommel. In field tests conducted in central Florida, clay wastes containing approximately 4 pct solids have been consolidated to greater than 20 pct solids. The rate at which PEO-treated material continues to dewater in a mine cut was also monitored. Preliminary results indicate that PEO-treated material will dewater to 30 pct solids in 80 days. Pretreatment of phosphatic clay waste with lime lowers the PEO dosage required for dewatering. This report is based upon work done under an agreement between the University of Alabama and the Bureau of Mines.

RI 9017. Triboelectric Effects on Polyethylene Methane Drainage Pipelines, by A. A. Campoli, J. Cervik, and R. L. King. 1986. 14 pp. 20 figs. The Bureau of Mines performed laboratory experiments to evaluate the triboelectric effect of particulate-laden gas streams on polyethylene pipe at various velocity, humidity, dust-size, and dust-load conditions. Charges in excess of 10 kV were produced on the outside and inside surfaces of laboratory pipe samples when exposed to 40 pct relative humidity (RH) gas stream containing coal dust. However, no charges were produced in laboratory tests that duplicated the over 75 pct RH and dust-free gas streams found in working underground pipelines. Bare copper wire, which is wound around the polyethylene pipe in a 1-ft (31-cm) spacing and grounded, eliminated the charge on the outside surface of the pipe, but not on the inside of the pipe surface.

RI 9018. High-Temperature Relative Enthalpies and Related Thermodynamic Properties of $Na_2Ti_6O_{13}$, by M. J. Ferrante. 1986. 6 pp. 1 fig. Relative enthalpies of high-purity disodium hexatitanate ($Na_2Ti_6O_{13}$) were measured at the Bureau of Mines to provide new thermodynamic data needed to advance the technology of materials. Measurements from 298.15 to 1,478 K were made by drop calorimetry with a copper block. Tabulated values are listed for the standard relative enthalpy, heat capacity, entropy, and Gibbs energy function between 298.15 and 1,500 K. Enthalpy data are also given in equation form and are combined with thermodynamic data from the literature to derive values of standard enthalpies of formation, Gibbs energies of formation, and logarithms of the equilibrium constants of formation. Similar calculations were made for the reaction of Na_2O with TiO_2.

RI 9019. In Situ FT-IR Studies of Reactions of Activated Sphalerite With Aqueous Solutions of Potassium Ethylxanthate, by S. C. Termes and P. E. Richardson. 1986. 11 pp. 14 figs. The Bureau of Mines has used Fourier transform infrared spectroscopy (FT-IR) to study in situ reactions of aqueous solutions of potassium ethylxanthate with Cu(II)- and Pb(II)-activated sphalerite plates, in which the plates were both the infrared-transparent windows and the reacting surfaces. A copper (I) ethylxanthate formed predominantly with Cu(II)-activated sphalerite, regardless of the activation time. The products formed on Pb(II)-activated sphalerite depended on the activation times; a short activation time (30 min) yielded a lead ethylxanthate-like product, but a long activation time (90 min) yielded a considerable amount of dixanthogen.

RI 9020. Calcium Chloride-Oxygen Leaching and Metals Recovery From an Arsenical Copper-Cobalt Concentrate, by G. A. Smyres, R. L. Kral, K. P. V. Lei, and T. G. Carnahan. 1986. 21 pp. 9 figs. A $CaCl_2$-O_2 leaching procedure and metal-recovery method for treating an arsenical Cu-Co sulfide concentrate was developed by the Bureau of Mines as an alternative to smelting, which is no longer considered an environmentally acceptable method for treating arsenic-containing ores. The procedure involved leaching in a $CaCl_2$ solution with $CaCO_3$ for 96 h at 26 pct solids (concentrate and $CaCO_3$), 115° C, and a pressure of 50 psig (345 kPa) with oxygen. More than 98 pct of the cobalt and 97 pct of the copper were extracted, and 99.98 pct of the arsenic and 99.9 pct of the iron remained in the leached residue. A filtration rate of 2.9 gal/(ft²·h) [118 L/(m²·h)] and a cake formation rate of 36 lb/(ft²·h) [172 kg/(m²·h)] were obtained by filtering reacted pulp at 100° C. More than 99 pct of the copper in the pregnant solution was extracted as $CuCl_2$ by solvent extraction with a new copper extractant. Copper was stripped from the loaded organic with a sulfate-chloride solution, which was used as the anolyte for electrowinning of copper in a membrane cell. Copper plate produced was more than 99.99 pct pure and required 0.81 (kW·h)/lb Cu [1.78 (kW·h)/kg Cu]. Cobalt sulfide was precipitated at pH 3 with $Ca(HS)_2$.

I 28.5/2:

RI 9021. Flocculation and Dewatering of Montmorillonite Modified by Ion Exchange, by D. A. Stanley and B. J. Scheiner. 1986. 10 pp. 10 figs. The Bureau of Mines is investigating a method of dewatering flocculated fine-particle waste that involves treating the waste with a high-molecular-weight polymer such as polyethylene oxide (PEO) followed by dewatering on a static screen and/or in a trommel. Dilution of the polymer solution used for dewatering and use of the ion-exchanged form of the montmorillonite clay were found to be major factors determining the amount of polymer required to dewater clay-containing slurries. The amount of polymer, A, required to dewater ion-exchanged montmorillonite can be described by the equation, $A^n = kC + b$, where n, k, and b are empirical constants and C is the concentration of the polymer solution used for dewatering. Clays that require large amounts of polymer for dewatering also dewater to a lower solids content. The concentration of the polymer solution is important because it affects the radius of the polymer coil in solution and hence its ease of transfer to a bridging configuration by shear. The constant, n, a function of the charge to hydrated radius of the exchange ion, relates to the strength of the bond between the polymer and the surface of the clay through a water bridge. The constant k is related to the hydrated radius for sodium or to the unhydrated radius for the other exchange ions. This report is based upon work done under an agreement between the University of Alabama and the Bureau of Mines.

RI 9022. Recovery of Silver, Gold, and Lead From a Complex Sulfide Ore Using Ferric Chloride, Thiourea, and Brine Leach Solutions, by R. G. Sandberg and J. L. Huiatt. 1986. 14 pp. 12 figs. The Bureau of Mines investigated a hydrometallurgical procedure to recover gold, silver, and byproduct lead from a complex lead-zinc sulfide ore. A ferric chloride ($FeCl_3$) preleach, at 40° C in 6 h, extracted about 50 pct of the zinc and formed insoluble silver and lead chlorides. Subsequent acid thiourea leaching, for 1 to 3 h at 40° C, extracted about 85 pct of the gold and silver. Lead chloride was solubilized from the remaining residue with NaCl brine solution at 55° C in 1 h. Lead metal was recovered from the brine solution in an electrolytic cell with an anion permselective membrane at a current efficiency of 95 pct and current density of 100 A/m^2. Spent $FeCl_3$ leach solution was reoxidized in the anode compartment at a current efficiency between 75 and 95 pct.

INFORMATION CIRCULARS

IC 9071. Economic Evaluation of an Electrolytic Process To Recover Lead From Scrap Batteries, by Thomas A. Phillips. 1986. 19 pp. 2 figs. This publication is an economic evaluation of the Bureau of Mines electrolytic process for recovering lead from scrap lead-acid batteries. In this process, scrap batteries are crushed and separated into metal and sludge fractions. The metal fraction is cast as anodes and electro-refined. Lead in the sludge fraction is converted to lead carbonate by reaction with an ammonium carbonate-ammonium bisulfite solution. The lead carbonate is then dissolved in a fluosilicic acid electrolyte from which pure lead metal is electrowon. A cost estimate is presented for a plant capable of processing 10,000 scrap batteries per day. The fixed capital cost for this plant is estimated to be $14 million on a fourth quarter 1984 basis. Operating costs are estimated to be $0.15/lb Pb recovered. Assuming a lead selling price of $0.17/lb, the interest rate of return on investment after taxes is 11 pct. A lead selling price of about $0.21/lb is needed to obtain a 20 pct interest rate of return.

IC 9072. Ground Subsidence and Structural Damage Over an Abandoned Room-and-Pillar Coal Mine at Hegeler, IL, by Gennaro G. Marino, James W. Mahar, Larry R. Powell, and Richard E. Thill. 1986. 24 pp. 21 figs. The Bureau of Mines and the University of Illinois investigated surface characteristics and damage to structures from mine subsidence over a room-and-pillar coal mine in Hegeler, IL. Data on three adjacent subsidence sags and associated structural damage were collected, summarized, and evaluated. The subsidence sags developed over a 10-year period and took place above a modified room-and-pillar operation mining the Herrin (No. 6) coal at a depth of 130 to 135 ft. Surface vertical displacements of 3.0 to 3.5 ft resulted from extracting 6.1 to 6.4 ft of coal. Ground movements associated with sag formation severely damaged three houses and a radio station building, broke numerous utility lines, and structurally distorted three radio transmission towers. The radio station was remodeled and the towers repaired, but the three houses were subsequently demolished. Surface waters collecting in the subsidence depressions caused failure of radial ground transmission systems. The following subsidence profile characteristics were determined at the radio station and one of the houses, respectively: profile slopes, 0.02 and 0.07; maximum curvatures, 2.3×10^{-4} ft^{-1} and 3.0×10^{-4} ft^{-1}; and angular distortions, 6.6×10^{-4} and 62.0×10^{-4}. Although the house was more severely damaged than the radio station, both structures are classified as severely to very severely damaged.

IC 9075. Field Tests of a Model Health and Safety Program for the Mining Industry, by Robert H. Peters and Louis Schaffer. 1986. 36 pp. 17 figs. The objective of the project described in this report was to design and field test a model health and safety program at a coal mining company and a gold mining company. The model program was implemented primarily by providing training on loss control, accident investigation, and the operation of mobile equipment, and by providing technical assistance to help solve health and safety problems. Data were obtained from company records on occupational injuries, illnesses, accidents, and "near misses"; and through direct observation of employees performing a large number of randomly selected jobs. At the coal mine, employees were observed five times over a 15-month period. At the gold mine, employees were observed six times over a 16-month period. During the study, the percentage of sampled jobs containing one or more safety deficiencies decreased from 74.3 pct to 36.6 pct at the coal mine and from 86.4 pct to 19.1 pct at the gold mine. Work on this project was performed by Woodward Associates, Inc., under a Bureau of Mines contract.

IC 9076. Coal Mine Roof Instability: Categories and Causes, by Noel N. Moebs and Raymond M. Stateham. 1986. 15 pp. 14 figs. Coal mine roof failure is categorized according to character, trend, or pattern of occurrence. Two principal categories of failure are proposed—geology related and stress related. Geology-related failure includes both lithology and structure. Each of several subcategories reflects the probable cause of failure and thereby provides a basis for the selection of appropriate techniques for reducing the incidence of failure. These control techniques, depending on local conditions, may include supplementary support, destressing, reduction of mine air humidity, or a change in the customary support methods.

IC 9079. Improved Backup Alarm Technology for Mobile Mining Equipment, by Guy A. Johnson, Russell E. Griffin, and Linneas W. Laage. 1986. 19 pp. 16 figs. Despite the use of warning alarms to alert miners to the backward movement of large mining equipment, miners still are injured too frequently in backup accidents. Currently approved backup alarm technology consists of continuous sounding alarm systems. New technology has developed a warning system that initiates an alarm only if there is an object close behind the vehicle. This advancement eliminates constant exposure to the alarm because a warning is given only in case of a potential collision. Adoption of this development can improve safety and reduce damage, especially for front-end loaders. It will also eliminate a source of nuisance noise in urban and residential areas. This Bureau of Mines report describes the general characteristics of infrared light, ultrasonic wave, and Doppler radar technology as used for backup alarms, and reviews the testing of the most promising detection devices.

BULLETIN

B 685. Dielectric Separation of Minerals, by C. E. Jordan and G. V. Sullivan. 1986. 17 pp. 25 figs. The fundamental properties of dielectric separation were studied to provide

insight into the design and operating characteristics of a dielectric separator. Force equations on mineral particles were derived and evaluated experimentally. Responses to variations in the electrical voltage and frequency, feed rate, particle size, dielectric fluid, and dielectric constant were tested theoretically and experimentally, using a 5-cm-diam dielectric separator. High-dielectric mineral recovery was proportional to the calculated effective dielectric force volume that surrounded each drum-electrode wire. Electrode spacing was the most sensitive design parameter; spacing of less than 0.4 cm was required for a good separation. Dielectric separation was effective for separating minerals with dielectric constants that differed by approximately 2 or more. This report is based upon work done under an agreement between the University of Alabama and the Bureau of Mines.

PREPRINTS FROM MINERALS YEARBOOK, 1985

These preprints are chapters from Minerals Yearbook, 1985. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

Bismuth, by James F. Carlin, Jr. 4 pp.
Kyanite and Related Materials, by Michael J. Potter. 4 pp.

II. Open File Reports—NTIS

An open file report is an unpublished Bureau of Mines report that has been made available as reference material. Any open file report may be inspected during working hours at the locations indicated but may not be removed, except that the Natural Resources Library, U.S. Department of the Interior, Washington, DC 20240, can usually supply copies on interlibrary loan. For further information, contact the library, 202–343–5815.

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AD/MI	**Assistant Director—Minerals Information, USBM, Washington, DC.**
AD/MMR	**Assistant Director—Minerals and Materials Research, USBM, Washington, DC.**
AD/MR	**Assistant Director—Mining Research, USBM, Washington, DC.**
AFOC/A	**Alaska Field Operations Center, USBM, Anchorage, AK.**
AFOC/F	**Alaska Field Operations Center, USBM, Fairbanks, AK.**
AFOC/J	**Alaska Field Operations Center, USBM, Juneau, AK.**
ALRC	**Albany Research Center, USBM, Albany, OR.**
AVRC	**Avondale Research Center, USBM, Avondale, MD.**
DOI	**U.S. Department of the Interior.**
DRC	**Denver Research Center, USBM, Denver, CO.**
IFOC	**Intermountain Field Operations Center, USBM, Denver, CO.**
LIB	**Natural Resources Library, DOI, Washington, DC.**
MSHA	**Mine Safety and Health Administration, Arlington, VA.**
NMH&SA	**National Mine Health and Safety Academy, Beckley, WV.**
OSM	**Office of Surface Mining Library, DOI, Washington, DC.**
PRC/B	**Pittsburgh Research Center (Bruceton), USBM, Pittsburgh, PA.**
RERC	**Reno Research Center, USBM, Reno, NV.**
RORC	**Rolla Research Center, USBM, Rolla, MO.**
SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 10A–86. Compact Loader/Trammer for Underground Metal and Nonmetal Mines. General and Design Review, by Tom Tallone. Aug. 1985. 93 pp. 49 figs. In the majority of metal and nonmetal mining operations, narrow vein deposits are being mined with slusher hoists. This method of mucking is costly, owing in part to its inherent labor intense operation and to its inability to muck 100 pct of the deposits. Mechanized equipment would greatly improve the material handling in narrow vein mining and would dramatically reduce the operational cost. The compact loader/trammer, known as the minimucker, has been developed to increase productivity of the load-haul-dump portion of the typical narrow vein mining cycle. This is volume I of the final report, a general and design review of the program activity. Research was done under contract J0205037 by Foster-Miller, Inc. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–193414; paper copy price code A05. $11.95.

OFR 10B–86. Compact Loader/Trammer for Underground Metal and Nonmetal Mines. Operation and Maintenance Manual, by Tom Tallone and Phil Quenzi. Aug. 1985. 28 pp. 24 figs. In the majority of metal and nonmetal mining operations, narrow vein deposits are being mined with slusher hoists. This method of mucking is costly, owing in part to its inherent labor intense operation and to its inability to muck 100 pct of the deposits. Mechanized equipment would greatly improve the material handling in narrow vein mining and would dramatically reduce the operational cost. The compact loader/trammer, known as the minimucker, has been developed to increase productivity of the load-haul-dump portion of the typical narrow vein mining cycle. This is volume II of the final report, an operation and maintenance manual for the minimucker. Research was done under contract J0205037 by Foster-Miller, Inc. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–193422; paper copy price code A03. $9.95.

OFR 56–86. Research on Water Proportioning for Dust Control on Longwalls, by Eric G. Kok and Roger F. J. Adam. Feb. 1986. 138 pp. 49 figs. Compliance with respirable dust standards is presently a critical problem in many longwall faces equipped with double drum shearers. Results are

presented of research performed to increase the quantity and optimize the distribution of the water supplied to the shearer drums to control the shearer operator dust exposure. The effect on the total respirable dust produced by the shearer was also examined. During the research effort, a simple and inexpensive manually controlled valve system was designed and implemented on a shearer to distribute the water supplied to the shearer drums. Research showed that increases in water quantities are beneficial, but associated pressure increases may induce respirable dust boilover, thus negating potential advantages. Other essential parameters such as location of shearer operator, outside spray orientation, and air quantity were considered in the evaluation. Research was done under contract J0318096 by Ketron, Inc. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Copies of this report will not be available for purchase.

OFR 64–86. A Study of the Precipitation of Platinum From Dilute Aqueous Solution, by Harold Ray Jouett II. 1984. 55 pp. 7 figs. Hydrogen sulfide gas was used to precipitate platinum sulfide from a dilute aqueous platinum solution. The precipitation was carried out in a continuous mixed suspension, mixed product removal precipitator. The platinum sulfide precipitate formed a stable colloidal suspension. The average particle size was about 7 nm. The purpose of this research was to be able to control and predict the size distribution of particles formed during the platinum sulfide precipitation. A mathematical model based on a steady-state particle population balance that relates the particle size distribution to nucleation and growth kinetics and operating parameters was compared with experimental particle size distributions. The model did not predict the observed size distributions. A qualitative model based on the Brownian motion of the particles and their electrostatic interactions is proposed to explain the observed size distributions. Addition of electrolytes to the colloidal suspension of platinum sulfide caused the particles to flocculate and form large, easily filtered particles. The higher the cation valence, the more effective it was as a flocculating agent. The problem with using electrolytes as flocculating agents is that the metal cations contaminate the flocculated platinum sulfide particles. Research was done under grant G1125132–3209 at Iowa State University. Available for reference at AD/MMR, LIB, and RERC. Copies of this report will not be available for purchase.

OFR 65–86. Leaching of Platinum and Palladium From Spent Automotive Catalysts, by David R. Tyson. 1984. 42 pp. 7 figs. The rate of reaction and the extent of reaction were investigated for the dissolution of platinum and palladium from spent automotive catalysts. Empirical rate expressions were obtained from mass balances and the concentration-time data. The rate for both platinum and palladium was high at early stages of leaching and decayed rapidly up to about 110 min and 50 min, respectively. The rate remained very low after these times while proceeding to zero. The extent of reaction for both platinum and palladium was affected by leaching solution composition and bed height and/or catalyst weight. The extent of reaction for palladium increased for increasing ratios of $(HCl):(HNO_3)$ and decreasing bed heights. The extent of reaction for platinum increased for decreasing ratios of $(HCl):(HNO_3)$ and decreasing bed heights. The catalyst particle size did not appear to affect the extent of reaction for either platinum or palladium. Research was done under grant G1125132–1901 at Iowa State University. Available for reference at AD/MMR, LIB, and RERC. Copies of this report will not be available for purchase.

OFR 66–86. Extraction of Palladium(II) Using Cyanex 471 Extractant and Supported Liquid Membrane, by Reed Dee Walker. 1984. 59 pp. 9 figs. The purpose of this report is to describe the recovery of palladium from spent automotive palladium-platinum catalysts. A type of liquid membrane separation process for the separation and concentration of metals—supported liquid membrane—was used to separate and concentrate very low concentrations of palladium(II) in hydrochloric acid solution against its concentration gradient. Using Cyanex 471 as the carrier and to clarify the permeation mechanism of palladium through the membrane, the separation of dilute solutions of palladium(II) chloride was carried out by (1) liquid-liquid extraction and (2) the use of supported liquid membrane containing the mobile carrier. In both cases, the operating conditions were varied so that the effect of such variables as HCl concentration, Cyanex 471 concentration, stripping agent concentration, temperature, palladium concentration, and platinum(IV) addition to the feed solution could be studied. Research was done under grant G1125132–2901 at Iowa State University. Available for reference at AD/MMR, LIB, and RERC. Copies of this report will not be available for purchase.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 18–86. Mineral Resources of the Indian Pass and Picacho Peak Study Areas, Imperial County, California, by Claytor M. Rumsey and Arel B. McMahan. 1986. 28 pp. 3 figs. Western Field Operations Center, Spokane, WA.

MLA 37–86. Mineral Resources of the Clifty RARE II Wilderness Study Area (L8039), Menifee and Wolfe Counties, Kentucky, by Richard F. Kness and Robert A. Welsh, Jr. 1986. 29 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

MLA 44–86. Mineral Investigation of a Part of the Sierra Ladrones Wilderness Study Area (NM–020–016), Socorro County, New Mexico, by John T. Neubert. 1986. 69 pp. 9 figs. Intermountain Field Operations Center, Denver, CO.

MLA 45–86. Mineral Investigation of a Part of the Eagletail Mountains Wilderness Study Area (AZ–020–128), La Paz, Maricopa, and Yuma Counties, Arizona, by Michael E. Lane. 1986. 16 pp. 5 figs. Intermountain Field Operations Center, Denver, CO.

MLA 46–86. Mineral Investigation of a Part of the Woolsey Peak Wilderness Study Area (AZ–020–142/144), Maricopa County, Arizona, by John R. McDonnell, Jr. 1986. 14 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

III. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 60–86. Sulfur Spray Coatings, by William C. McBee, Thomas A. Sullivan, and Harold L. Fike. Ch. 50 in Corrosion and Chemical Resistant Masonry Materials Handbook, ed. by Walter Lee Sheppard, Jr. Noyes Publ., Park Ridge, NJ, pp. 659–668. Sulfur spray materials have been developed as protective coatings for construction materials exposed to corrosive acid and salt environments. The development has included laboratory design and testing and the scale-up to large-scale field installations using special equipment and application techniques. Surface-bond construction using sulfur spray coatings has been shown to be technically feasible. Block buildings constructed by this method have structural properties exceeding those of buildings constructed with mortar joints.

OP 61–86. Polymer Concretes, by William C. McBee, Thomas A. Sullivan, and Harold L. Fike. Ch. 33 in Corrosion Resistant Masonry Materials Handbook, ed. by Walter Lee Sheppard, Jr. Noyes Publ., Park Ridge, NJ, pp. 392–416. Technology has been developed to prepare chemical-resistant construction materials. A modified-sulfur cement was developed in which sulfur is reacted with dicyclopentadiene and oligomers of cyclopentadiene to form a stable cement product. Mixture designs utilizing corrosion-resistant aggregates and modified-sulfur cements were developed to prepare stable sulfur concretes for use as corrosion-resistant materials of construction. Sulfur concretes were produced with excellent resistance to damage by most acid and salt environments, good mechanical strength properties, resistance to damage by freeze-thaw cycling, and coefficients of expansion compatible with those of other materials of construction such as portland cement concrete and reinforcing steel. The technology has been demonstrated on a commercial scale both in the manufacture of the modified-sulfur cement and in its utilization in producing sulfur concrete construction materials. Cooperative evaluation with industry on testing in corrosion environments indicated that sulfur concrete has the potential for widespread application in the chemical, metallurgical, and fertilizer industries.

OP 62–86. A New Construction Material To Consider—Sulphur Concrete, by K. W. Mlynarski and W. C. McBee. Navy Civ. Eng., v. 25, No. 4, Spring 1986, pp. 24–26. Corrosion-resistant sulfur concrete materials have been developed for use in acidic and salt environments where portland cement concrete (PCC) materials fail. Industrial testing has shown that these materials are durable in 50 different process environments. The materials exhibit excellent mechanical properties when compared with PCC. Sulfur concrete shows great promise for applications in the chemical, metallurgical, and fertilizer industries. Other potential use areas include marine environments and highway and bridge areas where salt corrosion is a problem.

OP 63–86. Transmission Electron Microscopy of Rapidly Quenched Iron-Aluminum Sputter-Deposited Films, by L. D. McCormick, P. M. Fabis, and C. L. Chien. J. Non-Cryst. Solids, v. 81, 1986, pp. 155–161. Sputter-deposited Fe-Al alloys were studied with transmission electron microscopy (TEM), Auger electron spectroscopy, and selected area electron diffraction (SAD). The alloys were deposited with thicknesses of approximately 50 nm onto carbon-coated TEM grids. All samples were deposited by planar magnetron sputtering onto substrates held at liquid nitrogen temperature. The compositions studied were $Fe_{70}Al_{30}$, $Fe_{50}Al_{50}$, $Fe_{30}Al_{70}$, $Fe_{10}Al_{90}$ and Fe_5Al_{95}. The $Fe_{70}Al_{30}$ composition was polycrystalline body-centered cubic (bcc) with a lattice constant of 0.291 nm, and the Fe_5Al_{95} composition was polycrystalline face-centered cubic (fcc) with a lattice constant of 0.41 nm. The $Fe_{50}Al_{50}$ composition contained approximately 2 vol % bcc crystallites in an amorphous matrix. Both the $Fe_{30}Al_{70}$ and $Fe_{10}Al_{90}$ samples were amorphous to TEM and SAD. The amorphous alloys and the amorphous regions of the $Fe_{50}Al_{50}$ alloys display an "island-channel" structure that is detectable with TEM. The data indicate the presence of only three phases in this metastable system: polycrystalline bcc, amorphous, and polycrystalline fcc.

OP 64–86. Flocculation, by B. J. Scheiner. Min. Eng., v. 38, No. 5, May 1986, pp. 342–343. Publications in the field of flocculation as applied to mineral processing for the year 1985 are reviewed. Many of the theoretical factors effecting flocculation such as polymer dosage, mineral consumption, and charge density of the polymer were discussed. Also, new flocculation techniques for dewatering mineral processing waste are included in the review. The research conducted in 1985 has increased understanding of how polymers interact with minerals.

OP 65–86. Overview of the Bureau of Mines Subsidence Research Program, by Michael A. Trevitz, Roger L. King, and Bradley V. Johnson. Paper/Presentation No. 86 in the Proceedings of the 88th Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Montreal, Canada, May 11–15, 1986, 14 pp. During the process of subsidence, the ground surface is changed as a result of the excavation of the underlying coal unit. The final surface profile is determined by a multitude of factors, such as extracted coal thickness, width of the opening, depth, overburden lithology, mine design, and mining method. An analysis of the typical subsidence profile reveals that almost every point of the surface over the mining area will be displaced both horizontally and vertically. Furthermore, mining operations have often been accused of causing local water wells to become dry or polluted. The impact on water can be of major proportions in such areas as the Western United States, where underground aquifers represent a major source of water for populated areas, and in the Midwest, where slight alterations in surface drainage could radically affect the agriculture industry. The Bureau of Mines Subsidence Research Program is focusing on providing the mine operator with the ability to predict surface movements and effects on ground water as a function of mining method and geologic context. The program is designed for coal basins where high mining activity may impact land use requirements. These areas have been delineated via consultations with industry and other Government agencies. Eventually, all coal basins and mining methods will be addressed. Data sets from several subsidence monitoring sites have been or are now being collected. Data sets are now available from the Eastern, Interior, and Rocky Mountain coal provinces for full-extraction mining methods (longwall and/or room-and-pillar with retreat mining). At select sites, shallow-aquifer monitoring wells have also been installed to observe the effects of subsidence on the ground water system. To date, an empirical model for subsidence prediction has been generated for the Northern Appalachian coal region. The applicability of this model to other coal regions remains to be tested.

IV. Patents

These patents, which may be used by any U.S. citizen or organization without royalty payment upon authorization by the U.S. Department of the Interior, were developed by Bureau scientists or under contracts with the Bureau. Application should be made to—

Branch of Patents
Division of General Law
Office of the Solicitor
U.S. Department of the Interior
Washington, DC 20240

U.S. Pat. 4,567,763. Passive Encoder for Range Knobs. William H. Schiffbauer. Feb. 4, 1986.

U.S. Pat. 4,588,565. Separation of Lithium Chloride From Impurities. Lawrence E. Schultze, Donald J. Bauer, and Ronald M. Arington, May 13, 1986.

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INFORMATION CIRCULARS

IC 9070. Gold Availability—World. A Minerals Availability Appraisal, by Paul R. Thomas and Edward H. Boyle, Jr. 1986. 87 pp. 37 figs. The Bureau of Mines evaluated the long-term cost and availability of primary gold production from 135 mines and deposits worldwide. Collectively, the evaluated countries represent 93 pct of world gold production. Total recoverable gold available (as of January 1984) from a subset of 111 significant producing mines and developing deposits in 13 market economy countries (MEC's) is estimated at 810 million tr oz. The Republic of South Africa is estimated to account for 87 pct of total recoverable gold. The United States and Canada account for 4 and 4.5 pct of the total, respectively. Eighty-three percent of total recoverable gold is available at a constant 1984 break-even price of $400/tr oz, and 70 pct is available at $300/tr oz. South Africa accounts for 90 pct of the gold available at $400/tr oz or less. Major conclusions are that (1) South Africa should remain the largest world producer through the year 2000, (2) annual MEC output in 2000 should not be significantly different than current output given constant 1984 gold prices of more than $300/tr oz, and (3) there may be a significant decline in production after 2010 in the absence of major new discoveries and continued development of new mines to offset the depletion of the South African mines. GPO Stock No. 024–004–02164–1. $4.50.

IC 9082. Mineral Consumption Forecasting: Standardizing and Comparing Forecasts, by John B. Bennett. 1986. 17 pp. 2 figs. This Bureau of Mines report presents a method of standardizing forecasts of mineral consumption that attempts to resolve the problems caused by the use of different data bases, different definitions of minerals consumption, and different base years for making projections. Using this method, forecasts of U.S. and world mineral consumption, in the year 2000, for nine commodities (aluminum, chromium, cobalt, copper, manganese, nickel, tin, tungsten, and zinc) are standardized and compared. Also, selected forecasts or associated growth rates are used to generate implied values of consumption for 1980–83, which are then compared with actual values of consumption for 1980–83. The economic growth predictions underlying these forecasts are examined, and some general conclusions are drawn. A description of each methodology used to generate these forecasts is given in an appendix. GPO Stock No. 024–004–02165–9. $1.50.

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REPORTS OF INVESTIGATIONS

RI 9023. Reclaiming Heavy Metals From Wastewater Using Magnesium Oxide, by D. N. Tallman, J. E. Pahlman, and S. E. Khalafalla. 1986. 13 pp. 7 figs. The electrokinetic properties of MgO have been utilized to simultaneously filter suspended solids and remove trace amounts of dissolved heavy metals from synthetic mine water. Greater than 95 pct removal of metals from influent at neutral pH containing 1 to 6 mg/L of dissolved Cd, Cu, Mn, Ni, and Zn can be routinely achieved by filtering through a granular bed of MgO at flow rates typical of rapid sand filtration (0.3 cm/s). Filtrate concentrations of most metals can be maintained below 0.1 mg/L for 160 bed volumes or more loading. The more mobile metals (those with larger solubility products) are more difficult to remove, and are strongly bonded to the MgO granules so that chemical stripping with chelating agent is required to clean the bed. Less mobile ions are easily removed by the filter and are effectively stripped by conventional filter backwashing. The fraction of metals recovered by chemically stripping the loaded MgO filters correlates to the zero points of charge of the metals. This process may be applicable to removal and recovery of trace amounts of heavy metals in mine drainage that is partly neutralized by liming. Also, since many of these metals are critical and strategic, the technique can be adapted not only to recycle process water from mineral and milling waste streams, but also to reclaim their metal values.

RI 9024. Solubility of Anhydrous $AlCl_3$ in $TiCl_4$ and VCl_4, by Dennis A. Hansen and Davis E. Traut. 1986. 8 pp. 7 figs. The solubility of anhydrous aluminum chloride in solutions of titanium tetrachloride and vanadium tetrachloride was determined as part of a research project by the Bureau of Mines to make a homogeneous alloy sponge of titanium, vanadium, and aluminum. Solubility curves were established using an autoclave at 75°, 100°, 125°, and 150° C. The solubility of $AlCl_3$ in $TiCl_4$ is 0.2 wt pct at 75° C; it increases to 18.3 wt pct at 150° C. The data concur with data from earlier researchers of this binary system for 75° to 125° C. For the VCl_4-$AlCl_3$ binary system, the solubility of $AlCl_3$ is 0.1 wt pct at 75° C, increasing to 1.6 wt pct at 150° C. For the $TiCl_4$-$AlCl_3$-VCl_4 ternary system, the solubility of $AlCl_3$ decreases from the values found with a pure $TiCl_4$-$AlCl_3$ system to the lower values found with a pure VCl_4-$AlCl_3$ system at the respective temperatures.

RI 9025. Recovery of Vanadium, Uranium, and Phosphate From Idaho Phosphorite Ores, by J. C. Judd, R. G. Sandberg, and J. L. Huiatt. 1986. 15 pp. The Bureau of Mines investigated the recovery of vanadium, uranium, and phosphorus from low-grade phosphorite ores and concentrate by leaching

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with H_2SO_4. Samples containing 0.12 to 0.23 pct V_2O_5, 0.009 to 0.012 pct U_3O_8, and 18 to 30 pct P_2O_5 were treated by batch-agitation leaching, roasting followed by acid leaching, salt-roasting followed by acid leaching, and leaching under pressure. Maximum recoveries using leaching alone ranged from 78 to 98 pct of the V_2O_5 and 74 to 88 pct of the U_3O_8. Leaching under pressure resulted in extractions of 88 to 95 pct of the V_2O_5 and 84 to 89 pct of the U_3O_8. Leaching following roasting—with or without NaCl—produced extractions of 97 to 99 pct of the V_2O_5 and 86 to 91 pct of the U_3O_8. Depending on the technique(s) employed, phosphate extractions ranged from 89 to 99 pct. Solvent extraction laboratory tests were conducted to selectively recover vanadium and uranium values from acid leach solutions. An average of 95 pct of the U_3O_8 was recovered using di(2-ethylhexyl)phosphoric acid, plus trioctylphosphinic oxide. Essentially all of the V_2O_5 was recovered with octylphenyl acid phosphate plus isodecanol. The phosphate remained in the raffinate.

RI 9026. Effects of Millisecond-Delay Intervals on Vibration and Airblast From Surface Coal Mine Blasting, by John W. Kopp and David E. Siskind. 1986. 44 pp. 38 figs. A major concern with blasting at surface mines is generation of ground vibrations and airblast and their effects on nearby residences. This Bureau of Mines report looks at the use of millisecond delays in blast design and their effect on the resulting ground vibrations and airblast. A total of 52 production blasts were instrumented and monitored at a surface coal mine in southern Indiana. Arrays of seismographs were used to gather time histories of vibrations and airblast. The data were analyzed for peak values of vibration and airblast and for frequency content. Various delay intervals were used within and between rows of blastholes. Delay intervals within rows were 17 and 42 milliseconds (ms) and those between rows ranged from 30 to 100 ms; these intervals are equivalent to 0.5 and 1.3 ms/ft within rows and 1.2 to 4.3 ms/ft between rows. Subsonic delay intervals within rows reduced airblast by 6 dB. Large delay intervals between rows reduced the amplitude of ground vibrations; their frequency depended primarily upon the geology of the minesite.

INFORMATION CIRCULAR

IC 9077. Dust Control on Longwall Shearers Using Water-Jet-Assisted Cutting, by C. D. Taylor, P. D. Kovscek, and E. D. Thimons. 1986. 9 pp. 6 figs. The Bureau of Mines equipped a longwall shearer with a water-jet-assisted cutting system and measured dust levels during the cutting of a simulated coal block. The block was cut dry at a conventional water spray pressure of 190 psi and with water-jet-assisted cutting pressures ranging from 1,000 to 6,000 psi. At water pressures of 3,000 psi and higher, dust concentrations were reduced by as much as 85 pct via water-jet-assisted cutting in comparison with conventional water sprays. This reduction was achieved without any increase in the water flow rate.

PREPRINTS FROM MINERALS YEARBOOK, 1985

These preprints are chapters from Minerals Yearbook, 1985. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

Beryllium, by Deborah A. Kramer. 5 pp.
Cadmium, by Patricia A. Plunkert. 6 pp.
Calcium and Calcium Compounds, by Lawrence Pelham. 5 pp.
Gallium, by Deborah A. Kramer. 5 pp.
Iron Oxide Pigments, by Donald P. Mickelsen. 11 pp.
Mercury, by Linda C. Carrico. 7 pp.

III. Open File Reports—NTIS

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USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 42A–86. Optimizing Water Sprays for Dust Control on Longwall Shearer Faces, by S. K. Ruggieri, T. L. Muldoon, W. Schroeder, C. Babbitt, and S. Rajan. Oct. 1983. 156 pp. 83 figs. Effective control of respirable dust is one of the

most serious problems associated with longwall mining in the United States. The major reason is that face workers work in the airstream downwind of the major dust source—the longwall shearer cutting drum. The major approach to dust control has been the increased use of water sprays for dust suppression. These sprays, however, can make conditions worse by creating turbulence and mixing, which forces the dust cloud into the operator's breathing zone. The air upstream of the shearer is clean. If this flow could be divided with one split confining and carrying away the dust cloud and the second split blowing over the operators, their dust exposures would be reduced. This report describes the laboratory development and field evaluation of a system that accomplishes this airstream split. The system combines the use of barriers and water sprays to split the airflow and to confine the dust cloud in the dirty split in the face side of the shearer. The system, known as the shearer clearer, has shown a 50% reduction in shearer-generated dust measured at the operators. Research was done under contract J0308019 by Foster-Miller, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-205408; paper copy price code A08. $16.95.

OFR 42B–86. Optimizing Water Sprays for Dust Control on Longwall Shearer Faces—Design and Installation Manual, by S. K. Ruggieri and C. Babbitt. Oct. 1983. 79 pp. 33 figs. This user's manual contains the following practical information concerning improved water spray systems for dust control on longwall shearers: (1) description and capabilities, (2) design, (3) installation, (4) testing and modification, and (5) operation and maintenance. All of the systems and techniques described are aimed at reducing the respirable dust exposure of the shearer operators from shearer-generated dust sources. Information is provided on upgrading water supply systems, making more efficient use of cooling water and drum spray systems, and using a shearer clearer passive barrier system to control shearer dust. The shearer clearer is an improved water spray system that consists of strategically mounted water sprays and passive barriers (conveyor belting). The system reduces the dust concentrations in the operator's walkway by splitting the airflow on the upwind side of the shearer and confining the dust cloud to the face side of the shearer. All of the systems and techniques presented have been installed on operating longwalls and are practical and fieldworthy. Extensive underground evaluations, tests by MSHA, and independent installations by coal producers have confirmed the performance of the shearer clearer system. The system has shown reductions of 50% in shearer-generated dust measured at the operators' positions. Research was done under contract J0308019 by Foster-Miller, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-205416; paper copy price code A05. $11.95.

OFR 43–86. Monitoring and Control of Mine Air Diesel Pollutants: Summary of Michigan Technological University Research, by J. H. Johnson and D. H. Carlson. June 15, 1985. 49 pp. 18 figs. This report references reports and publications from 1975 to 1985 that are related to the diesel underground mine air quality research undertaken by Michigan Technological University. Research results obtained on this contract are summarized in five different sections: (1) development of a systematic approach to monitoring, data analysis, and interpretation for diesel mine air quality control; (2) experimental evaluation of load-haul-dump (LHD) on-board air quality control systems; (3) development of a portable self-contained LHD tailpipe emissions measurement apparatus for NO_2, NO, CO, CO_2, and particulate matter; (4) quantitative analysis of diesel and coal particulate matter by laser Raman spectroscopy; and (5) development and application to detector tubes of a laboratory method to assess accuracy of occupational diesel pollutant concentration measurements. Research was done under contract J0199125 at Michigan Technological University. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-204104; paper copy price code A03. $9.95.

OFR 44–86. Research Study on Pillar Design for Vertical Crater Retreat (VCR) Mining, by William G. Pariseau. Oct. 1985. 233 pp. 112 figs. A 4-year study was conducted of the rock mechanics aspects of two underground hard-rock mine study stopes: (1) Anaconda Minerals Co.'s Carr Fork Mine near Tooele, UT, and (2) Homestake Mining Co.'s Homestake Mine in Lead, SD. Large-diameter (6½-in) blastholes were an integral part of the stoping method at each mine. A true vertical crater retreat (VCR) method was used at the Homestake Mine, while a vertical bench mining method (VBM) was used at the Carr Fork Mine. Since there are no personnel in a VCR or VBM stope, all ground control including dimensioning of stopes and pillars and the layout of cable bolt assays or other artificial support must be done in advance of production blasting. Accordingly, the objective of the research study was the establishment of a procedure for optimizing stope and pillar sizes. The approach taken in each case was a combination of mine measurements of the study stope response to mining, laboratory testing for rock properties and in situ stress measurements of the premining stress field, and theoretical calculations of the study stope response to mining. All calculations were done with the UTAH-II finite element computer program. Simulation of the blasting sequence gave a correlation of 0.88 between measured and calculated extensometer readings (incremental relative displacement) at the Carr Fork Mine where over 30 instrumentation boreholes were used to monitor the test stope response. A correlation of 0.84 was obtained at the Homestake Mine where 19 instrumented boreholes were used for monitoring purposes. These high correlations validated the computer model and calibrated it for rock mass properties. The calibrated model was then used in parametric studies of alternative design layouts. Research was done under contract J0215043 at the University of Utah. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-210960; paper copy price code A11. $22.95.

OFR 45–86. EM Rescue (Location) System for Deep Mines Phase II—Build and Test Breadboard Equipment, by F. B. Curry, T. C. Moore, L. H. Rorden, and I. D. Schleicher. Oct. 1984. 106 pp. 25 figs. The purpose of this program is to extend electromagnetic (EM) techniques for use in locating miners trapped in mines as deep as 1,000 m. A previously developed EM system is considered adequate for use in mines less than 300 m deep where it has a probability of detection of 54%. A system for deep mines must keep underground equipment simple and use extremely low frequencies (ELF), sensitive receivers, and noise cancellation. The proposed location method is based on vector field measurements from two or more static sensors and computation of source location by iterative techniques. During phase II, very sensitive search coil sensors were built and used in a separate test to verify the feasibility of atmospheric noise cancellation. A breadboard location system version without cancellation, which is a fieldable test bed to evaluate receiving and location functions, was tested and supplied. Very good results were achieved from the first in-mine test with the transmitter at a depth of 380 m. Research was done under contract J0199009 by Develco, Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86-215902; paper copy price code A06. $16.95.

OFR 47A–86. A Quality Program Plan for Explosion-Proof Electrical Enclosures. Part 1—Final Technical Report, by William D. Dodge and P. A. Cox. Nov. 1984. 128 pp. 10 figs. A typical quality program plan is presented for explosion-proof (XP) electrical enclosures. A quality program plan is a document traditionally prepared by a manufacturer to describe the manner in which it intends to meet the quality requirements imposed on its product by contract, purchase order, or government agency provisions. The plan is suggested for manufacturers of XP enclosures that are to be certified by MSHA for mining use. The plan describes the quality system,

organization, and implementing mechanisms that are to be applied in the manufacture and delivery of certified XP enclosures. Example forms and example procedures are included. Research was done under contract H0387009 by Southwest Research Institute. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-209509; paper copy price code A07. $16.95.

OFR 47B-86. Thermally Induced Stresses in Explosion-Proof Electrical Enclosures With Windows. Part 2—Final Technical Report, by Stephen E. Stewart, F. D. Lin, and P. A. Cox. Nov. 1984. 119 pp. 75 figs. This report presents the solutions to linear transient thermal and stress analyses of explosion-proof enclosures used in underground mines. The results were used to assess the severity of certification tests for enclosure windows relative to possible loads occurring in the actual mine environment. Cast iron electric light enclosures with polycarbonate and glass windows were analyzed under steady-state thermal conditions (light burning) and for thermal shocks corresponding to an internal explosion (ignition of volatile mine gas) or external quenching (mine water spray system). Thermal shocks to the enclosure, caused by ignited gases or water spray, were applied via a series of load steps in the transient analysis. The temperature dependence of material properties and of the film heat transfer coefficients were included in the model. The work demonstrates that thermally induced stresses are strongly influenced by the way the window is mounted in the enclosure. It also shows that the MSHA Thermal Shock Tests, if performed on an unsupported lens (or window), produces lower stresses than the lens (or window) may experience in the mine environment. Research was done under contract H0387009 by Southwest Research Institute. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-209517; paper copy price code A06. $16.95.

OFR 47C-86. A Design Guide for Explosion-Proof Electrical Enclosures. Part 3—Final Technical Report, by P. A. Cox and W. R. Schick. Dec. 1985. 353 pp. 53 figs. Guidelines are provided for the design of explosion-proof electrical enclosures that will meet MSHA certification requirements according to Part 18, Title 30, of the Code of Federal Regulations, and fulfill their intended service underground. The guide covers only those aspects of design that affect enclosure strength, ruggedness, endurance, and flame path, i.e., the enclosure ability to properly contain an internal explosion. Internal static and explosion pressures and external impact and thermal heating loads are treated, as well as the proper selection of materials and welding procedures. Research was done under contract H0387009 by Southwest Research Institute. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-209525; paper copy price code A16. $28.95.

OFR 47D-86. Testing of Adhesives and Polycarbonate Lenses in a Simulated Mine Environment. Part 4—Final Technical Report, by Charles H. Parr, Donald N. Weed, and P. A. Cox. Nov. 1985. 69 pp. 28 figs. A testing program was conducted to determine the suitability and reliability of adhesives and polycarbonate (PC) lenses for extended use in luminaires in mine environments. Polycarbonates were exposed, for periods up to 36 months, to four environments including ultraviolet light, humidity, intermittent water spray, and heat of either 180° F or 240° F in various combinations. Izod impact tests on the exposed lens material indicated that polycarbonate functions well under all 180° F environments and could be used with confidence for periods exceeding the test period, for as long as 10 years, with a suitable safety factor employed in design. The specimens exposed at 240° F showed decreased toughness after 24 months' exposure. Extrapolation of these data was deemed to be risky. A 462-day compatibility test between polycarbonate and six hydraulic fluids was run on stressed PC beams. One fluid caused beam breakage in less than 1 day, while three caused breakage at intermediate times. Two fluids exhibited essentially no effect on the PC when compared with a control. Epoxy and silicone adhesives were tested as lens adhesives and sealants. Three epoxy combinations tested showed low and erratic failure stresses. A room-temperature-cure silicone adhesive functioned extremely well for the time periods up to 36 months and temperatures up to 240° F. Research was done under contract H0387009 by Southwest Research Institute. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-209533; paper copy price code A04. $11.95.

OFR 49A-86. Evaluation and Improvement of Electrical Storm Warning Systems, by R. L. Johnson, W. M. Sherrill, J. D. Moore, and D. E. Janota. Nov. 1979. 107 pp. 36 figs. An analysis of mining explosive accident reports indicates a need for clear and ample warning of approaching electrical storms to reduce injuries and/or fatalities due to lightning-induced premature detonation. During the spring and summer of 1979, six lightning warning devices were comparatively evaluated at three test sites. The devices tested were (1) flash counter, (2) corona point, (3) radioactive probe, (4) field mill, (5) azimuth and range locator, and (6) triangulation locator. The test sites were chosen to provide system evaluation under varied thunderstorm conditions. The devices were tested at San Antonio, TX; Kennedy Space Center, Cape Canaveral, FL; and Langmuir Laboratory near Socorro, NM. Comparative performance evaluation is reviewed in terms of alarm reliability, false alarm, and failure to alarm probabilities. Improved lightning warning system requirements and methods of relating warning criteria to explosive hazard are discussed. Research was done under contract J0387207 by Southwest Research Institute. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-203619; paper copy price code A06. $16.95.

OFR 49B-86. Evaluation and Improvement of Electrical Storm Warning Systems—Warning Parameter Study, by R. L. Johnson and W. M. Sherrill. Dec. 1981. 17 pp. 4 figs. The data acquired under phase 2 of the subject contract were analyzed to investigate whether the electric field strength and/or abrupt changes in the electric field could be used as device-independent parameters for a lightning warning safety specification. Although the data analyzed were device specific, the following conclusions were reached: (1) A safety specification based upon the electric field strength at a single point is ineffective; the specification must also include an area of coverage that implies the use of multiple sensors. (2) A safety specification based upon flash rate or relative magnitude of received atmospherics is ineffective owing to the large variability in the measurement parameter. (3) A safety specification based upon an indication of atmospheric electrical activity within a predetermined radius of the site is viable and does not attempt to solve the difficult problem of estimating the location of the activity. Research was done under contract J0387207 by Southwest Research Institute. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-203775; paper copy price code A02. $9.95.

OFR 50-86. Results of 1984 Bureau of Mines Site Specific Mineral Investigations in the Valdez Creek Mining District, Alaska, by Mark P. Meyer. 1986. 29 pp. 2 figs. During 1984, the Bureau of Mines conducted site specific mineral investigations in the Valdez Creek Mining District, AK. This study included a literature search and reconnaissance level field investigations. The literature search identified 243 mines, prospects, and occurrences within the Valdez Creek Mining District. During the field reconnaissance, 19 samples were collected from 5 deposits: Denali Copper Prospect, Valdez Creek Placer Mine, Black Creek Gold Mine, Windy Creek Placer Prospect, and Timberline Creek Gold Mines. Research was done by the Bureau of Mines Alaska Field Operations

Center. Available for reference at AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 86–203858; paper copy price code A03. $9.95.

OFR 53–86. Dual Wavelength Light Sources, by R. T. Boos, W. D. Egan, R. A. Elliott, and R. K. DeFreeze. Oct. 1985. 160 pp. 37 figs. This report describes work done to develop a tunable, room-temperature diode laser source for a remote coal mine methanometer. A detailed evaluation showed that a broad area InGaAs/InP injection laser operating at approximately 1,650 nm could be suitable for a differential absorption light detection and ranging measurement of methane if the spectral bandwidth could be reduced by a factor of approximately 400. Consequently, an external grating cavity was designed and fabricated to reduce the bandwidth of the injection lasers. The optical design of an off-axis parabolic mirror grating cavity was developed using geometric optics to determine the physical parameters for the external cavity that would produce the desired spectral bandwidth of 0.2 cm^{-1}. The fabrication of this external resonator source is described, and its performance against the design criteria is evaluated. Apart from a smaller than desired methane absorption coefficient, the device met all design specifications. The low methane absorption coefficient was attributed to a larger than desired source linewidth, which was measured to be two to three times larger than the design value. An explanation of this excessive bandwidth based on coupled mode theory is presented. The unsatisfactory methane absorption coefficient of the external cavity diode laser source significantly detracts from its suitability for use in an instrument to remotely measure methane in coal mines. Research was done under contract H0123031 by Bethlehem Steel Corp. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–209483; paper copy price code A08. $16.95.

OFR 54–86. Mineral Investigations in the Chugach National Forest, Alaska, by J. M. Kurtak and R. E. Jeske. Nov. 1984. 305 pp. 36 figs. The Bureau of Mines and the U.S. Geological Survey cooperatively studied the Chugach National Forest, Alaska, from 1979 to 1982 as part of the Roadless Area Review and Evaluation (RARE II) Program. The Bureau evaluated the mineral production potential of the area. This included literature and claim records research, field examination of all reported mines, prospects, and occurrences that could be located, followup of anomalous geochemical samples, and reconnaissance of terranes with little prospecting or mining history. This report covers the central 790,880 acres of the forest. Copper, with byproduct zinc, silver, and gold, has been the major metal produced from the study area as well as from the entire Chugach National Forest. The majority of the copper deposits are concentrated within basaltic rocks on Knight Island, but the major producers are hosted by sedimentary rocks on Latouche Island. Approximately 182.6 million lb of copper, 1.5 million oz of silver, and an unknown but substantial amount of gold were produced during a 30-year period. Currently no mines in the area are producing. Reserves with mineral production potential total 4.6 million tons, with grades of 1.6% copper, 0.30 oz silver/ton, and 0.04 oz gold/ton. Research was done at the Bureau of Mines Alaska Field Operations Center at Anchorage. Available for reference at AD/MDA, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Copies of this report will not be available for purchase.

OFR 55–86. Improving the Performance of Tunnel, Raise and Shaft Boring Machines for Coal Mine Applications, by Levent Ozdemir. Mar. 1986. 178 pp. 64 figs. A 6-ft-diam laboratory tunnel, raise, and shaft boring machine was designed and constructed to carry out research investigations to enhance the performance of mechanical rock excavation equipment. The machine is operated with a computer control system and features extensive instrumentation to monitor and record various test parameters, including triaxial cutter forces, machine thrust, torque, revolutions per minute, and penetration rate. An extensive laboratory testing program has been conducted using this machine, demonstrating the feasibility of attaining high rates of penetration in various sedimentary geologies. Also, a large data base has been developed to serve as a basis for the improved design and performance of tunnel, raise, and shaft boring equipment. Research was done under contract J0133919 at the Colorado School of Mines. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–216678; paper copy price code A09. $16.95.

OFR 57–86. Development of Rollover Protective Structures (ROPS) Performance Criteria for Large Mobile Mining Equipment, by John L. Dahle and Gary R. Gavan. Apr. 1985. 277 pp. 139 figs. This report documents the research efforts undertaken to design, construct, and test rollover protective structures (ROPS) and to develop ROPS performance criteria for large mobile mining machines. The following tests were conducted: two rollover tests of a 52,000-pound machine, two rollover tests and one static test of a 390,000-pound machine, and one rollover test of a 286,000-pound machine. The tests were conducted on a specially constructed hill with a slope of 35° and were designed to provide consistent and repetitious results. Each roll test was designed to provide a minimum of 540° of machine rotation about the longitudinal axis, allowing the ROPS to impact the slope twice. All tests included extensive instrumentation and photographic coverage to fully evaluate the performance of the ROPS. Using data obtained from the testing, as well as all other available rollover data in which ROPS loading and energy absorption characteristics were known, recommended performance criteria were developed, including side force and energy, longitudinal force, and vertical force. Research was done under contract H0292020 by Woodward Associates, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–216066; paper copy price code A13. $22.95.

OFR 58–86. Development of High Voltage Permissible Loadcenter, by D. Randolph Berry and Bobby Gillenwater. Feb. 1986. 136 pp. 48 figs. This report makes recommendations for new approval and testing criteria for high-voltage permissible loadcenters (transformer and switchgear, greater than 4,160 V) for underground U.S. mines and describes the development and testing of a prototype loadcenter to meet the criteria. The recommended criteria included new findings in several areas: minimum clearances between live conductors, special precautions for using organic insulators, tests for dielectric strength and electrical stress, and explosion testing. A research test program was conducted to evaluate the pressure rise caused by a high-energy arcing fault (10,000 A) with and without a simultaneous methane-air explosion inside the enclosure. The prototype loadcenter included a 1,250-kV•A, 7,200-V primary transformer inside a center compartment with separate, attached enclosures for high-voltage switchgear on one end and low-voltage distribution and protection on the other end. A comprehensive literature search was conducted, and a state-of-the-art review of research and industrial experience with high-voltage explosion-proof transformers is included. Research was done under contract H0308093 by Foster-Miller, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–215803; paper copy price code A07. $16.95.

OFR 59–86. Performance and Test Criteria for DC Fuses—Phase II, by Allan Levins. Aug. 1985. 113 pp. 20 figs. The objective of this research was the development of test criteria for direct current (dc) fuses used for protecting trailing cables in coal mines. Using data developed in an earlier study, a preliminary set of requirements for such fuses was established. Interested parties such as fuse manufacturers, mining equipment manufacturers, and mine operators were contacted and asked to comment on the preliminary requirements. Fuses were tested using these preliminary requirements, and the viability and reasonableness of the test procedure were judged. A

meeting of representatives of fuse manufacturers, a mine operator, the Mine Safety and Health Administration, and the contractors for phases I and II of this effort was held. From the information gained to that date and the comments made at the meeting, final proposed test criteria for mine duty fuses were established. Research was done under contract J0328019 by Underwriters Laboratories Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–215811; paper copy price code A06. $16.95.

OFR 60–86. Analysis of Miners' Job Attendance Behavior and its Relationship to Miners' Accidents and Injuries—Final Report, by Paul S. Goodman. Oct. 1985. 278 pp. 49 figs. This report examines coal miner absenteeism and its relationship to accidents and injuries at underground mines. A total of 19 mines participated in various phases of this 3-year project. Miners at the participating mines ranged in number from 185 to 776. The data consisted of the mines' daily attendance records and detailed interviews with approximately 50 miners from each mine. The interviews contained questions about the miners' satisfaction with various on-the-job and off-the-job factors, their perceptions of the mines' absenteeism policies, the reasons or causes for their own absences, and the miners' demographic characteristics. Accident and injury data from six mines were used in parametric and multiple regression analysis of the absenteeism-accident relationship. The data represented activity during approximately 80,000 miner-days worked. Strategies for reducing absenteeism are discussed. Research was done under contract J0328033 by Carnegie-Mellon University. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–216306; paper copy price code A13. $22.95.

OFR 61A–86. Investigation of Quartz Dust Sources and Control Mechanisms on Surface Coal Mine Operations. Volume I—Results, Analysis, and Conclusions, by Robert A. Zimmer and Stan R. Lueck. Mar. 1986. 72 pp. 7 figs. The basic objective of this study was to evaluate the sources of airborne quartz dust during removal of overburden at surface coal mines to which the highwall driller, drill helper, truck driver, and bulldozer operator are exposed. Testing was conducted at 11 mine locations. Both dry and wet control systems for overburden drills were evaluated at the various mines. The test results showed that both control systems are capable of achieving greater than 95% control under certain conditions. On dry systems, a nearly linear inverse relationship was found between shroud height and control efficiency. Control efficiencies ranged from 41% to 99% over the 0- to 27-in height range evaluated. Dry systems performed most efficiently when the shroud was positioned as close to the ground as possible. For wet systems, measured control efficiencies ranged from 9% at a water flow rate of 0.2 gal/min to 96% at 1.2 gal/min. Water flow rates greater than 1.0 gal/min were found to cause operational problems. Quartz concentrations of the respirable particulate ranged from below detectable limits to 13.6%. Quartz concentrations did not change appreciably by mine, by filter location, or with the use of control equipment. Data summaries and the analyses of data are presented in volume I. Research was done under contract J0348032 by PEI Associates, Inc. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–215852; paper copy price code A04. $11.95.

OFR 61B–86. Investigation of Quartz Dust Sources and Control Mechanisms on Surface Coal Mine Operations. Volume II—Appendices, by Robert A. Zimmer and Stan R. Lueck. Mar. 1986. 370 pp. 2 figs. The basic objective of this study was to evaluate the sources of airborne quartz dust during removal of overburden at surface coal mines to which the highwall driller, drill helper, truck driver, and bulldozer operator are exposed. Testing was conducted at 11 mine locations. Both dry and wet control systems for overburden drills were evaluated at the various mines. The test results showed that both control systems are capable of achieving greater than 95% control under certain conditions. On dry systems, a nearly linear inverse relationship was found between shroud height and control efficiency. Control efficiencies ranged from 41% to 99% over the 0- to 27-in height range evaluated. Dry systems performed most efficiently when the shroud was positioned as close to the ground as possible. For wet systems, measured control efficiencies ranged from 9% at a water flow rate of 0.2 gal/min to 96% at 1.2 gal/min. Water flow rates greater than 1.0 gal/min were found to cause operational problems. Quartz concentrations of the respirable particulate ranged from below detectable limits to 13.6%. Quartz concentrations did not change appreciably by mine, by filter location, or with the use of control equipment. Volume II contains basic data. Research was done under contract J0348032 by PEI Associates, Inc. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–215860; paper copy price code A16. $28.95.

OFR 62–86. Additives for Strengthening Backfill Materials in Steep Coal Seam Mining, by C. E. Brechtel, D. A. Thies, and J. R. Aggson. Sept. 1985. 116 pp. 22 figs. A testing program was conducted to design a cemented backfill for hydraulic placement in underhand cut-and-fill mining of a steeply dipping coal seam. The testing evaluated the use of three different backfill aggregates, locally available at the coal mine, with portland cement and five different pozzolans, including a Class F fly ash, a Class C fly ash, a cement kiln dust, and ground smelter slag. Both viscosity and uniaxial compressive strength of backfill mixtures with different pozzolan and portland cement contents were used to evaluate their suitability. Based upon the results of preliminary testing, an optimum mixture of alluvial sand with 6% portland cement and 10% Class F pozzolan was chosen for further compression testing. Research was done under contract J0245006 by J. F. T. Agapito & Associates, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–215894; paper copy price code A06. $16.95.

OFR 63–86. Geologic Conditions Affecting Coal Mine Ground Control in the Western United States, by R. B. Laird, A. L. Amundson, G. J. Colaizzi, and L. M. Bithell. Dec. 1985. 200 pp. 63 figs. A comprehensive investigation was conducted into geologic features affecting coal mine ground control in western underground coal mines. This study involved a literature search for data on geologic features affecting coal mine ground control, western coal geology associated with specific geologic features, and MSHA roof fall information. Data on mining operations were collected through interviews with mining and research personnel. Selected mines were toured within 10 coalfields in Utah and Colorado. This final report summarizes western coal depositional environments and geological structures and describes mining and geology for the coalfields studied. All observed geologic features and conditions related to coal mine ground control are described in terms of their depositional or structural origin, morphology, diagnostic characteristics, associated adverse mining conditions, and roof control methods. Photographic documentation of these geologic features is included. Adverse geologic features and their locations are correlated with geological environments by coalfield to define their relative impact on mining operations. Comprehensive bibliographical data and selected MSHA roof fall data are also included. Research was done under contract J0145032 by Goodson & Associates, Inc. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–217171; paper copy price code A09. $16.95.

OFR 67–86. Lead Reduction in Ambient Air: Technical Feasibility and Cost Analysis at Domestic Primary Lead Smelters and Refineries, by Richard D. Smith, Orville A. Kiehn, David R. Wilburn, and Robert C. Bowyer. May 1986. 75 pp. 5

figs. The Bureau of Mines evaluated the technology and capital investment and annual operating costs of emission control for further reductions of lead in ambient air at the Glover, Herculaneum, and Buick smelter-refineries in Missouri and the East Helena, MT, smelter. This study seeks to analyze the technology available to the domestic primary lead industry for attempting to further reduce lead emissions below 1985 levels. Through enclosure of concentrate unloading and handling areas and all lead processing buildings, followed by venting these enclosures to the atmosphere through baghouses and the application of appropriate local controls, lead inventories can theoretically be reduced by 2,424 pounds per day from 1985 levels. Using conventional technology, aggregated additional capital costs of $250,014,000 and annual operating costs of $18,507,800 are estimated for the four operations, resulting in a total cost of $0.063 per pound of refined lead. Continuous drossing techniques would assist in meeting OSHA standards in process areas. Continuous drossing would increase capital and operating costs to $258,344,800 and $16,104,700, respectively, for a total cost of $0.062 per pound of refined lead. The open market price for refined lead for the first quarter of 1986 was $0.184 per pound. Research was done by the Bureau of Mines. Available for reference at AFOC/A, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-216447; paper copy price code A05. $11.95.

OFR 68-86. Instrumented In-Mine Testing of the Bureau of Mines Low-RPM, Deep-Cutting Continuous Mining Machine, by James M. Burkes. Sept. 1982. 125 pp. 45 figs. The Federal Coal Mine Health and Safety Act of 1969 established maximum airborne respirable dust exposure levels for underground coal mines. In an effort to provide the knowledge needed to achieve compliance without reducing productivity, the Bureau of Mines has sponsored research oriented toward improving mining machines. This work has consistently shown that a deep-cutting, low-rpm (revolutions per minute) continuous miner can reduce respirable dust levels without production penalties. To provide the design data by manufacturers to produce versions of the deep-cutting machine, a prototype miner was instrumented and in-mine tests were conducted. The data acquisition system developed for this testing allowed real-time monitoring of selected machine parameters to include cutterhead bit forces, power levels, structural loads, and pressures. During the in-mine tests, these parameters were recorded for a wide range of operating conditions. Test variables were advance rate, bit lacing, and head rotary speed. Analysis of the test data was performed to quantify the characteristics in terms useful to the designers of continuous mining equipment. Peak, average, and root-mean-square values for power, torque, rpm, boom loads, and bit loads were computed. Research was done under contract H0282020 at Southwest Research Institute. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86-216587; paper copy price code A07. $16.95.

OFR 69-86. Development of a Water Jet Assisted Cutterhead for Coal Measure Rocks, by Levent Ozdemir. Apr. 1986. 95 pp. 46 figs. The results of a laboratory research program aimed at the development of a water jet assisted drag bit cutting system for coal mine applications are presented. Two types of drag bits, a conical and a plow bit, were tested in a hard sandstone rock with jet pressures of up to 20,000 psi. Jet locations investigated were in front of and behind the bits. For each jet mounting location, three jet impingement distances with respect to bit tip were tested. The closest jet impingement location to bit tip was found most effective, providing the greatest force reductions on the bit. Overall, significant bit force reductions up to 50 percent were obtained with jet assist. Also observed was a drastic reduction in airborne dust when jets were employed. Research was done under contract J0233900 at the Colorado School of Mines. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86-217692; paper copy price code A05. $11.95.

OFR 71-86. Maps Summarizing Land Availability for Mineral Exploration and Development in South-Central Alaska, 1985, by Robert G. Bottge. May 27, 1986. 2 maps. These maps show land within the Tanacross and Tanana quadrangles that was open to mineral exploration and development as of July 1, 1985. As many as 15 other land subclassifications are depicted, as well as restrictions, private lands, and land closed to mining. The mineral deposits plotted are based on the Bureau of Mines Minerals Availability System (MAS). Included are tables keyed to deposit numbers identifying one or more mineral deposits within a 3-mile radius. The table also includes the MAS sequence number (to relate it to Bureau files), major commodities associated with the deposit, and an indicator of past production. Available for reference at AFOC/A, AFOC/F, and AFOC/J. Copies of these maps will not be available for purchase.

OFR 72-86. Using ADA (Accident Data Analysis) in Mine Safety Research, by E. T. Bowers. June 1986. 111 pp. 7 figs. This report describes the Accident Data Analysis (ADA) computer program developed at the Spokane Research Center to provide a rapid broad-based analysis of mining accidents. Because the Bureau of Mines often needs this type of information for the development of viable research programs, the ADA program was written to access and analyze accident data available from the Labor Department's Mine Safety and Health Administration. This report describes the ADA program, the data it uses, and the potential value it has for planning mining research. Research was done by the Bureau of Mines Spokane Research Center. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Copies of this report will not be available for purchase.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 48-86. Mineral Resources of the Duncan Creek Study Area, Owyhee County, Idaho, by Richard A. Winters and Andrew M. Leszcykowski. 1986. 9 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 49-86. Mineral Resources of the Big Jacks Creek Study Area, Owyhee County, Idaho, by Richard A. Winters and Andrew M. Leszcykowski. 1986. 9 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 50-86. Mineral Resources of the Little Jacks Creek Study Area, Owyhee County, Idaho, by Richard A. Winters and Andrew M. Leszcykowski. 1986. 9 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 51-86. Mineral Investigation of the Sierra de las Canas Wilderness Study Area (NM-020-038), Socorro County, New Mexico, by Stanley L. Korzeb. 1986. 9 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MINERAL INSTITUTES REPORTS

The mineral institutes program operates under Public Law 98-409 and under title III of Public Law 95-87. It is designed to improve the quality of mineral engineering research and education through support for research in mining, metallurgical processing, and related mineral sciences. The Bureau of Mines supports this research through annual allotment grants, matched by non-Federal funds, to mineral institutes at 31 universities throughout the United States and by research grants to these institutions to address specific mining and processing problem areas.

The following reports describe research conducted under research grants. Individual copies may be available from the authors of the papers at the university cited. Copies of these reports are NOT available from the Bureau of Mines.

MIR 1–86. Yield Pillar Simulation Using Physical Modeling, by Dwayne C. Kicker and Duk-Won Park. June 1986. 8 pp. 10 figs. As the use of longwall mining increases in the United States, there is a need to better understand the stress redistributions indicative of this method. To control high stress concentrations, the yield pillar concept has been developed. A physical longwall mine model has been designed to study the effect of yield pillars in deep mining. The model includes sensitive stress measuring devices, a new excavating technique, and a new model material. This study includes the use of both regular and yield pillar systems and has successfully simulated the mode of stress change in chain pillars.

MIR 2–86. Stability Analysis of Entries in a Deep Coal Mine, by Duk-Won Park and Nadim F. Ash. Oct. 1985. 10 pp. 9 figs. Strain-softening behavior of rock and coal layers around a coal mine opening was simulated using a quasi-elastic approach that accounts for residual strength after failure. This simulation was achieved in such a way that material values were modified after each run, according to stress distribution, until the simulation reached an equilibrium condition. MSC/NASTRAN Finite Element Method program was used for the simulation. The effect of a yield pillar system was analyzed in comparison with a regular pillar system. The results agreed with the field measurement in terms of stress distribution and floor heave.

MIR 3–86. Physical Model Study of a Longwall Mine, by Duk-Won Park and Dwayne C. Kicker. Oct. 1985. 11 pp. 11 figs. In this study, a new physical model for longwall mining is developed combining features of the "sandbox" model with a new concept for excavation of mine openings using a special tool. The model is used to examine stress distributions around a longwall face in chain pillars as well as in the panel. Reproducible results are obtained, which enable a successful simulation by the model of the mode of stress changes in chain pillars, and measurement of the development of panel front abutment.

IV. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 66–86. Design Procedure for Arch Canopies for Rehabilitation of High-Roof-Fall Areas, by Richard A. Allwes and C. P. Mangelsdorf. Paper in Proceedings of the Fifth Conference on Ground Control in Mining, Morgantown, WV, June 11–13, 1986, ed. by A. Wahab Khair and Syd S. Peng. WV Univ., 1986, pp. 51–61. This report describes an arch canopy design for rehabilitating a high-roof-fall area. This procedure is specifically developed for evaluating an unbackfilled arch canopy that is subjected to an impact load (roof fall). Only dynamic line loading of the arch canopy at its crown is considered, and the procedure does not account for an unsymmetrical loading condition. The evaluation of whether an arch canopy is suitable for a particular installation is dependent upon many variables, including in-mine conditions and the engineering properties of the structure. However, a general evaluation can be based upon a comparison of the arch's maximum crown deflection and a prescribed allowable crown deflection. A single spring-mass system is used as an idealized model to represent the dynamic behavior of the arch canopy at its crown. An energy approach is taken to determine the maximum crown deflection of an arch rather than solving a differential equation of motion derived from dynamic equilibrium. The design procedure is based on the concept that when an arch canopy is subjected to impact loading at its crown and deflects from its unloaded state to maximum crown deflection, the structure absorbs strain energy, both elastic and plastic. As a result, this strain energy can be calculated from a static load-displacement diagram for the structure. The significance of this design procedure is that it gives mine personnel an analytical tool to select an arch canopy to meet the dimensional and functional requirements of a mine entry, and a prescribed allowable crown deflection.

OP 67–86. Equations for the Analysis of Borehole Pressure Cell Data, by C. O. Babcock. Ch. 36 in Rock Mechanics: Key to Energy Production, ed. by Howard L. Hartman (Proc. 27th U.S. Symposium on Rock Mechanics, Tuscaloosa, AL, June 23–25, 1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 233–241. Although hydraulic pressure cells in boreholes have been in extensive use since 1957, methods of data reduction have been slow to develop. Recent research indicates a linear relationship between cell pressure change and rock stress change. In this paper, the logarithm of the cell pressure is related to the stress change in seven elastic materials, and equations derived from this experiment to relate borehole pressure cell data from vertical and horizontal cells to biaxial ground stress changes are presented.

OP 68–86. Performance and Test Criteria for DC Fuses in Coal Mine Applications, by Tayfun Cataltepe, Eldon K. Stanek, Dennis O. Wiitanen, and Michael R. Yenchek. IEEE Trans. Ind. Appl., v. IA–22, No. 2, Mar.–Apr. 1986, pp. 352–359. A comprehensive study was made of direct current (dc) system parameters in coal mines to recommend performance and test criteria for dc fuses. Field tests were conducted in 10 coal mines in which transients were initiated on the dc system from which the parameters of the dc mine electrical power system could be determined. Data processing was done to fit an exponential curve to the field waveforms. From this data analysis finding, the dc system resistance, inductance, and time constant was possible. A survey of nationally recognized laboratories was conducted to establish that the recommended test criteria were practical. The development of test criteria for dc fuses used in mines was based on the measurement of parameters in the field, the survey of testing laboratories, literature searches, and laboratory tests. Methods to predict analytically the parameters measured in the field are discussed. A brief laboratory testing program was carried out to verify the practicality of the recommended criteria.

OP 69–86. Closing the Door on Dust, by Andrew B. Cecala and Terry Muldoon. Pit and Quarry, v. 78, No. 11, May 1986, pp. 36–37. Although bag technology is continually improving, contamination from bags remains a significant source of dust exposure for workers. Most of the bag contamination is caused by the bag valve. Standard paper, polyethylene, extended polyethylene, double trap, and foam valves were tested for dust reduction capabilities during bag loading, conveying, and pallet loading at a mineral processing plant. When extended polyethylene valves were used, respirable dust at the bag operator location was reduced by 62%, while at the bag stacker location the reduction was 66%.

OP 70–86. Advances in Computerized Mine Monitoring and Control—Prospects for the Future, by T. J. Fisher and J. Durkin. Paper in Mining Productivity Through Reliability and Control. Volume 1. Technical Papers (Proc. Mining 85 Conference, Birmingham, England, June 23–25, 1985). Inst. Min. Eng., Birmingham, England, 1985, pp. 339–344. This paper describes recent advances in hardware and software used in U.S. monitoring systems and hypothesizes on developments from the field of artificial intelligence, such as expert systems, that may play an important role in future monitoring and control technology.

OP 71–86. Purification of Secondary Zinc Materials Contaminated With Chlorine, by J. P. Hager and J. F. Lemons, Jr. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 203–223.New process chemistry has been developed for the dechlorination roasting of secondary zinc materials. An experimental study has been undertaken on the use of gaseous

ferric chloride [$Fe_2Cl_6(g)$] to enhance the volatilization of impurity chlorides and zinc chloride through the formation of gaseous complexes. The species $CdFe_2Cl_8(g)$, $PbFe_2Cl_8(g)$, and $ZnFeCl_5(g)$ have been identified and their thermodynamic properties determined. To provide a baseline for the measurement of vaporization enhancement through vapor complex formation, the vapor pressures of $CdCl_2$, $PbCl_2$, and $ZnCl_2$ were also determined. The thermodynamic data have been used to calculate the degree of visibility enhancement for different processing conditions. The results indicate that significant increases in vapor pressure are possible. An information base has been developed that should provide for further development and commercialization of the processing concept.

OP 72–86. Structural Stability of Coal Mine Entry Intersections—Case Studies, by K. Hanna, D. Conover, K. Haramy, and R. Kneisley. Ch. 74 in Rock Mechanics: Key to Energy Production, ed. by Howard L. Hartman (Proc. 27th U.S. Symposium on Rock Mechanics, Tuscaloosa, AL, June 23–25, 1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 512–519. This paper describes a rock mechanics instrumentation program, data analyses, and a comparison of two case studies conducted at two underground mines, designated as "A" and "B," in the Illinois Coal Basin. The instrumentation plans and data collected during development and long-term monitoring of four-way intersections and adjoining entries are presented. Data analyses of premining and postmining roof stress, pillar loading, strata movement, roof bolt loading, and geologic features are included.

OP 73–86. Field Investigations of Roof and Pillar Stability in Coal Mine Intersections, by K. Hanna, J. Haramy, and D. Conover. Paper in Proceedings of Second Conference on Ground Control Problems in the Illinois Coal Basin, Southern Illinois University, May 29–31, 1985, ed. by Yoginder P. Chugh. Southern IL Univ., May 1985, pp. 76–83. This report describes a rock mechanics instrumentation program conducted in an underground coal mine in central Illinois. This research project was designed to provide a basic understanding of premining and postmining roof stresses, pillar loading, strata movement, floor heave, and bolt loading at coal mine intersections. The instrumentation plan, a description of the instruments installed in and around a four-way intersection, and the data obtained during the development of the intersection, are presented. Data collected include physical properties of coal and rock, strata lithology, strata movements, in situ stresses, mining-induced stresses, and roof bolt loading. An analysis of observations made and instrumentation results obtained during development and initial monitoring of the intersection is also presented.

OP 74–86. Effect of High Horizontal Stress on Coal Mine Entry Intersection Stability, by K. Hanna, K. Haramy, D. Conover, and D. Dopp. Paper in Proceedings of Fifth Conference on Ground Control Mining, Morgantown, WV, June 11–13, 1986, ed. by A. Wahab Khair and Syd S. Peng. WV Univ., 1986, pp. 167–182. This manuscript describes an extensive ground control study at the Inland Steel No. 2 Mine near McLeansboro, IL, conducted by the Bureau of Mines in cooperation with Inland Steel Coal Co. The mine experiences severe ground control problems primarily due to high horizontal stress, particularly at entry intersections. Mine experience has shown that reorienting mine entries, modifying the bolting pattern, and altering the mining sequence are effective in reducing the severity of roof falls and out-of-seam dilution. However, the frequency of roof falls has not been significantly reduced. This research project was designed to provide a thorough explanation of the intersection failure mechanism through combined analyses of company in-mine experience and Bureau field measurements. Stresses and deformations were monitored in a four-way intersection during all stages of development and were related to site observations and theoretical analyses.

OP 75–86. Floor Heave Analysis in a Deep Coal Mine, by K. Haramy and J. McDonnell. Ch. 75 in Rock Mechanics: Key to Energy Production, ed. by Howard L. Hartman (Proc. 27th U.S. Symposium on Rock Mechanics, Tuscaloosa, AL, June 23–25, 1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 520–525. This paper presents an analysis of rapid floor heave in a deep western coal mine. The analysis is based on field measurements, laboratory data, and beam design theory. Factors affecting floor heave, such as mining-induced stress, mine opening size, entry orientation, mine geology, rock physical properties, and gas pressure, are considered. Examination of floor heave in the mine indicates that heaving is primarily caused by deformation of a soft floor member that is subjected to high mining-induced stress. Theoretical analysis of in situ floor stresses resulting from overburden loading indicates that floor failure will occur. The analysis is confirmed by visual observations of floor heave in the mine. Recommendations for mine layout and opening design to control rapid, massive floor heave under these conditions are also presented.

OP 76–86. Recovery of Cobalt From Spent Copper Leach Solution, by T. H. Jeffers, K. S. Gritton, and P. G. Bennett. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 609–621. Cobalt, used in jet engine parts, tool steels, and catalysts, is a strategic and critical metal. The United States depends primarily on cobalt imported from Africa, but the long-term stability of that source is questionable. However, significant amounts of cobalt are present in some readily accessible spent copper leach solutions. For example, recovery of cobalt from existing streams at two U.S. copper leaching operations would yield about 1,500,000 lb/yr of cobalt, or 13 pct of our 1983 domestic consumption. The Bureau of Mines has developed a procedure using continuous ion exchange to extract cobalt from spent copper leach solution containing only 26 to 30 ppm Co. The effects of aqueous flow rate, resin flow rate, and column height on cobalt extraction were investigated. Cobalt extractions of 92 pct or higher were achieved at solution flow rates of up to 5.5 gpm/ft^2 of column cross-sectional area, and an aqueous-to-resin flow ratio of 40:1. Overall cobalt extraction increased as the column height increased, but cobalt extraction per unit of length was more efficient in a 12-ft-high column than in an 18-ft column. Solvent extraction procedures were utilized to purify and concentrate the ion exchange eluates and to produce a cobalt sulfate solution containing 80 g/L Co, 0.5 g/L Ni, and not more than 0.01 g/L Cu, Fe, Zn, or Al. Metallic cobalt cathodes containing over 99 pct Co were recovered by electrowinning this solution.

OP 77–86. Proposed Methods for Recovering Critical Metals From Spent Catalysts, by B. W. Jong and R. E. Siemens. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 477–488. The Bureau of Mines is investigating chlorination methods, various hydrometallurgical approaches, and pyrometallurgical roasting procedures to recover Ni, Mo, W, Cu, and Cr from spent hydroprocessing, hydrogenation, and high-temperature shift catalysts. Laboratory work to date has resulted in extraction of 73% to 99% of the metals from these wastes. Total processing schemes for recovering the metals have been proposed. Economic feasibility of the proposed processing schemes is being evaluated.

OP 78–86. An Overview of the Bureau of Mines Recycling Research, by Robert S. Kaplan. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 3-11. To meet its twin objectives of encouraging recycling and alleviating waste disposal problems associated with mineral and metallurgical processing, the Bureau of Mines conducts a varied and extensive research program. This program is conducted about 85 pct in-house and 15 pct in universities, colleges, and technical schools. Industrial input concerning program content is sought through contacts with trade associations, such as the National Association of Recycling Industries and the Institute of Scrap Iron and Steel, as well as with individual companies. Other sources of input include academia and other governmental organizations. The Bureau's program includes basic, long-range research to

advance technology in recycling. Broad based input to this program results in real world needs being addressed.

OP 79–86. Reclaiming Heavy Metals From Wastewater With Magnesium Oxide, by S. E. Khalafalla, J. E. Pahlman, and D. N. Tallman. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 227–246. The unusual electrokinetic properties of the magnesium oxide aqueous interface has been utilized to make superior filters for suspended solids and precipitants for heavy metals in wastewater streams. While the electrocapillary maxima, or points of zero charge, for most oxides and hydroxides are at a pH of about 6 (range 2.5 to 10.5), that of MgO is around pH 12.4. Lippmann's theory of electrocapillarity and the thermodynamics of surfaces would predict MgO to be positively charged at pH values below 12.4, while most other solids surfaces are negatively charged at pH values above 6. An electrokinetic attractive force between unlike charges has been found to aid in the removal of asbestos fibers and other solid particulates from water. Likewise, the basicity at the MgO surface is strong enough to precipitate many of the heavy and hazardous metals encountered in wastewater streams. Because the embryonic metal precipitates are negatively charged, many of them cement to the MgO surface, thus forming more compact sludges and much denser residues than obtained with lime, the traditional precipitant. Regeneration of the MgO filter and/or precipitant by backwashing and chemical stripping with EDTA would allow for the recovery of heavy metals in concentrated form. Since many of these heavy metals are critical and strategic, the technique can be adapted not only to recycling process water from mineral and milling waste streams, but also to reclaim their metal values.

OP 80–86. Sodium Production, by Dennis S. Kostick. Sec. in Encyclopedia of Materials Science and Engineering, ed. by Michael B. Bever. MIT Press, v. 6 (R–S), 1986, p. 4465. Sodium, discovered by Davy in 1807, is a soft, chemically reactive metal with a density of 0.97 g cm^{-3} and a melting point of 97.8B C. Metallic sodium is currently produced by the electrolysis of molten sodium chloride in the Downs cell, a process that was patented in 1924. The cell contains an anode and a cathode chamber with collectors to recover the chlorine gas that is evolved. The Castner cell, used exclusively until the 1920's, produced metallic sodium by the electrolysis of sodium hydroxide. This technique is still used in some areas of the world.

OP 81–86. Triaxial-Loading Measurement for Mine-Pillar Stability Eva'uation, by Paul H. Lu. Ch. 55 in Rock Mechanics: Key to Energy Production, ed. by Howard L. Hartman (Proc. 27th U.S. Symposium on Rock Mechanics, Tuscaloosa, AL, June 23–25, 1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 379–385. This paper proposes a novel method, "integrity factor approach," of mine pillar stability evaluation based on in situ triaxial-loading measurement. The pillar integrity factor is defined as the quotient resulting from division of integrated total pillar strength across the critical dimension by the integrated total pillar load across the same dimension. The integrity factor is dynamic, while the conventional safety factor is static. With this approach, the pillar stability can be evaluated at any stage of mining progress during panel operation. It automatically considers the progressive failure of the pillar and postfailure strength without the need to clearly define the boundary between yielded and intact zones of the pillar. Based on two case studies, the integrity factor approach is shown to be a practical, effective technique for evaluating stability of conventionally designed pillars. It is suggested that a more realistic estimate of in situ pillar strength could be made based on the combination of in situ triaxial-loading measurements and laboratory true triaxial compression tests, rather than through the traditional combination of biaxial-loading measurements and conventional triaxial compression tests.

OP 82–86. Recovery of Chlorine From Ferric Chloride, by Richard S. Olsen. Paper in Recycle and Secondary Recovery of Metals, ed. by Patrick R. Taylor, Hong Y. Sohn, and Noel Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 771–783. Chlorination of ilmenite to produce titanium products results in large quantities of byproduct ferric chloride. This finely divided, deliquescent material is extremely corrosive and presents a difficult waste disposal problem. In particular, it is difficult to transfer accurately and reliably for processing in fluidized-bed operations for chlorine recovery. Compacting ferric chloride into hard, dense pellets reduces its tendency to pick up moisture and allows it to be easily fed into oxidation units where it can be converted to iron oxide and recyclable chlorine. Pelletizing also allows the incorporation of promoters such as sodium chloride and fuels such as carbon or metallic iron within the feed pellets. Bench-scale studies in fluidized-bed oxidation reactors are described and discussed. A product gas containing 80 pct chlorine was produced at 800○ C in a reactor where pelletized ferric chloride was fed to the bottom of a fluidized bed of iron oxide.

OP 83–86. A New Seismic Probe for Coal Seam Hazard Detection, by W. R. Peters, T. E. Owen, and R. E. Thill. Soc. Min. Eng. AIME preprint 85–312, 1986, 7 pp. An experimental hole-to-hole seismic probe system has been developed for use in coal measure geology as a means of determining the structural conditions of coal seams. The source probe produces a 500-joule electric arc discharge whose seismic wavelet has a spectrum in the 200 to 2,000 Hz frequency range. Low compliance hydrophones contained in the source probe as well as in a separate seismic detector probe are matched to the frequency range of the source. Both probes are constructed with 5.72-cm-diameter housings. The transducers in the probes are equipped with fluid-inflatable boots to permit operation in either wet or dry boreholes. Preliminary tests in vertical boreholes drilled 213 m apart in sedimentary rock formations show reliable operation and useful seismic propagation measurements along horizontal and oblique paths up to 232 m in length. Because the seismic wavelet has an accurately repeatable waveshape, multiple shots and signal averaging techniques can be used to enhance the signal-to-noise ratio and extend the transmission distances.

OP 84–86. A Case History of Computer-Aided Lineament Analysis for Ground Control Planning, by D. C. Peters and R. A. Speirer. Paper in Proceedings of Fifth Conference on Ground Control in Mining, Morgantown, WV, June 11–13, 1986, ed. by A. Wahab Khair and Syd S. Peng. WV Univ., 1986, pp. 191–205. The Bureau of Mines has been researching remote sensing analysis of an underground coal mining area in Utah and computer-aided methods of defining ground control hazards in this mining area. As a result of these studies, a preliminary potential hazards map was developed for the test site. This map is based primarily upon a lineament (linear feature) analysis of Landsat satellite data. Other data used were paleochannel location data, resistivity data, and information from surface and underground field checking of the lineaments and ground control problems in the mine. Lineaments proved to be reliable indicators of hazardous areas, although the type and degree of hazard varies with different lineament trends and the presence of other conditions such as lineament intersections and intersections with other geologic structures or with paleochannels. Lineaments were observed to match faults, joints, and/or joint trends in the area. The paleochannel data, derived from drill-hole data, provided basic information about potentially hazardous areas in the mine by suggesting where paleochannels could cause instability in the roof rock. The ground control problem data served largely to define the relative degree of hazard associated with lineaments and the types of hazards encountered in the mine. Resistivity data helped confirm the presence of fractures where they were expected to occur both from surface geology and from the lineament data.

OP 85–86. Image Processing for Automatic Lineament Analysis, by D. C. Peters, R. A. Speirer, and S. H. Moll. Paper in Proceedings of Geotech '84, Denver, CO, October 10–12, 1984. Am. Inst. Prof. Geol., Denver, CO, 1986, pp. 88–91. This paper describes research by the Bureau of Mines on the use of remote sensing methods to evaluate potentially hazardous ground control conditions in underground mines.

Computer processing of image and nonimage data is used to provide an estimate of potential mine hazards by identification of surface lineaments related to geologic structures. This approach to lineament analysis by computer involves a refinement of Landsat images to enhance linear information contained within the image data and to suppress nonlineament data. Since lineaments exhibit a moderate change in brightness compared with their surroundings, these contrasts can be ignored. The remaining data are enhanced to exaggerate the lineament information by applying a series of square, high-pass filters of different sizes (to enhance lineaments of different lengths), complex contrast stretches, and edge enhancement methods. Line-plotting of these individual readings produces a map of the existing faults and fractures.

OP 86–86. The Illinois Bureau of Mines Cooperative Mine Subsidence Research Program, by Larry R. Powell and Paul B. DuMontelle. Paper in Proceedings of the Second Conference on Ground Control Problems in the Illinois Coal Basin, Carbondale, IL, May 29–31, 1985, ed. by Yoginder P. Chugh. Southern IL Univ., May 1985, pp. 13–17. This paper highlights past and present subsidence research projects within Illinois. The long-term research program developed and the management scheme devised to ensure efficient use of available research funds and expertise are presented. The program provides techniques for reliable subsidence prediction for both high-extraction mining, which results in immediate, planned subsidence, and room-and-pillar mining, in which no subsidence is anticipated.

OP 87–86. Use of Acoustic Velocity for Predicting Stress Under Uniaxial Compression, by K. S. Radcliffe, R. E. Thill, and J. A. Jessop. Soc. Min. Eng. AIME preprint 86-147, 1986, 11 pp. This report presents results for the first phase of an experimental program to study the feasibility of using acoustic velocity for predicting the state of stress in a rock mass. Compressional wave velocities were determined axially in cylindrical samples during uniaxial compression for several rock types conditioned in dry and water-saturated environments. Results indicate that in rocks containing compressible voids or cracks, substantial velocity change occurs with the application of stress in the lower (below 100 MPa) stress regime. The effect is normally nonlinear, however, and diminishes to asymptotic values when cracks or voids become closed, or with saturation. Empirical prediction equations were derived for each rock type by linear and nonlinear regression analyses, and correlation coefficients were calculated to determine the equations that best fit the stress-velocity data. The operational range for predicting stress using compressional wave velocity appears to be within the range of vertical stress expected in most shallow to intermediate depth mining operations (less than 1,000 m). Based on the experimental results to date and on theoretical considerations, it appears that the technology can be advanced to predict in situ stress based on acoustic P-wave velocity determinations in most mining situations.

OP 88–86. Pigments: Titania, Iron Oxides, and Other Minerals, by M. A. Schwartz. Sec. in Encyclopedia of Materials Science and Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 5 (O–Q), 1986, pp. 3529–3531. This article describes the nature and characteristics of titania and iron oxide, the two most widely used pigment materials, as well as other pigment minerals that can be synthesized or that exist in nature. Processing techniques and uses for these pigments are included.

OP 89–86. Remote Sensing Applications for Improved Mine Design and Ground Control, by R. A. Speirer, D. C. Peters, L. P. Richardson, and T. C. Bettinger. Ch. 6 in Engineering Health and Safety in Coal Mining, ed. by A. Wahab Khair (Proc. SME-AIME Annu. Meeting, New Orleans, LA, Mar. 2–6, 1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 45–59. The Bureau of Mines remote sensing researchers at the Denver, CO, Research Center have been investigating computerized methods to detect and map surface linear features called "lineaments" for ground hazard assessment in mines. Many of these lineaments at the test mine site were found to correlate to subsurface geologic discontinuities such as faults, fractures, and joints that intersect coal seams at depth. These features adversely affect the roof and rib integrity in underground mines, thus contributing to rock failures that may result in injuries to mine workers and loss of production. Advance knowledge of the existence of such hazardous geologic features can aid in mine planning and development.

OP 90–86. Influence of Lithology on Longwall Mining Subsidence, by S. Tandanand and L. R. Powell. Min. Eng., v. 36, No. 12, Dec. 1984, pp. 1666–1671. The U.S. Bureau of Mines assessed the geological effects on the ratio of maximum subsidence and extraction thickness, known as the subsidence factor, to develop a simple method for predicting the maximum subsidence. The study was restricted to the Northern Appalachian coal basin where data were collected from 13 coal mines. A model previously developed to relate the subsidence factor with the lithology and with the width and depth of working panels was used in the assessment. The result shows the possibility of determining maximum subsidence without resorting to a rigorous method.

OP 91–86. Effects of Water Saturation on Acoustic Wave Velocity, by R. E. Thill and J. A. Jessop. Soc. Min. Eng. AIME preprint 86-148, 1986, 13 pp. An ultrasonic, pulse-immersion apparatus and method are described for determining the effects of moisture on the dynamic elastic properties of rock. The method provides an alternative approach for assessing the moisture sensitivity of rocks. Ultrasonic wave velocities are continuously monitored in immersed rock samples as a function of water absorption and time up to saturation. Moisture effects on compressional wave velocity vary as a function of the type of rock and the time and amount of water absorption. Regression analyses are used to curve-fit plots of the data and to derive empirical expressions for compressional wave velocity as a function of water content for different categories of rock. Results indicate that compressional wave velocity can be used to predict both the moisture content and its effect on strength and deformational properties of rock. These results have potential for detecting or monitoring bad roof conditions in situations where the mine rock exhibits strength degradation with moisture absorption.

OP 92–86. Foundation Response to Subsidence Induced by High Extraction Mining in Southern Illinois, by Theodore L. Triplett, Ronald E. Yarbrough, and Larry R. Powell. Ch. 42 in Rock Mechanics: Key to Energy Production, ed. by Howard L. Hartman (Proc. 27th U.S. Symposium on Rock Mechanics, Tuscaloosa, AL, June 23–25, 1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 283–290. This paper describes the response of two foundations to ground movements induced by subsidence from a high-extraction retreat room-and-pillar operation in southern Illinois. The objective of this monitoring program was to study the interaction between the ground surface and a structure during a subsidence event. The monitoring instrumentation and techniques as they relate to the mining and site conditions are described, including the capability of a tiltmeter to detect and follow the tilt of the foundations caused by the mining subsidence sequence. Using data from this tiltmeter, the development of curvature in the foundations as they conform to the displaced ground surface is shown. This curvature is represented by differences in tilt as various points on the foundations, indicating a change in tilt over a horizontal distance. Also, even though subsidence damage has not been fully analyzed, preliminary observations of the cracks that formed in the foundations are reported.

OP 93–86. Instruments and Procedures for Monitoring Respirable Coal Mine Dust Concentrations, by Kenneth L. Williams. Paper in Proceedings of the Fifteenth Annual Institute on Coal Mining Health, Safety, and Research, VPI and State University, Blacksburg, VA, August 28–30, 1984, ed. by Michael Karmis, William H. Sutherland, J. Richard Lucas, David R. Forshey, and Gavin J. Faulkner. Dep. Min. and Miner. Eng., VPI and State Univ., Blacksburg, VA, 1986, pp. 115–130. This paper presents new information on the performance of the coal mine dust personal sampling unit, a brief description of some recently developed dust monitors, a summary of the most recent test results, and suggestions on how to best use respirable dust monitors, both new and old, in the mining environment.

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B 680. Investigation of Fire and Explosion Accidents in the Chemical, Mining, and Fuel-Related Industries—A Manual, by Joseph M. Kuchta. 1986. 84 pp. 87 figs. This Bureau of Mines manual is oriented to the technical needs of an investigation of fire or explosion accidents and includes various practical and theoretical information that is needed in analyzing accidents or evaluating conditions that might lead to an accident. It is applicable to accidents in the chemical, mining, transportation, and other fuel-related industries. Specific procedures for conducting an accident investigation are outlined, and various guidelines are given for developing the fire or explosion evidence. Ignitability, flammability, and physiochemical data are presented for over 500 combustible gases, liquids, and solids; empirical and theoretical expressions are also given for extrapolating the behavior of combustible-oxidant-diluent systems to various environmental conditions. In addition, various data pertinent to damage analysis are summarized to facilitate the task of the investigator in developing plausible accident scenarios. GPO Stock No. 024–004–02167–5. $4.50.

MINERALS YEARBOOK, 1984

Volume II. Area Reports: Domestic, prepared by the staff of the Bureau of Mines. 1986. 52 ch. 669 pp. This volume of the 1984 Minerals Yearbook contains chapters on the mineral industry of each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, and the Commonwealth of Puerto Rico. A statistical summary is also included in this volume. GPO Stock No. 024–004–02163–2. $24.

II. Free Publications

Application for free publications should be made to—

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REPORTS OF INVESTIGATIONS

RI 9027. Shield Mechanics and Resultant Load Vector Studies, by Thomas M. Barczak and Robert C. Garson. 1986. 43 pp. 54 figs. The term "resultant load vector" is defined as the representation of the forces applied to a longwall roof support element by strata activity through a single, quantifiable measure of support resistance. The relatively complex kinematics of the shield structure prohibit determination of support resistance simply from the summation of leg forces. In the research reported in this Bureau of Mines study, the mechanics of the shield structure were evaluated, and a technique was developed whereby the resultant shield loading could be determined by instrumenting supports with pressure transducers and strain gauges to measure leg, canopy capsule, and lemniscate link forces. This technique has been laboratory tested in the Bureau's Mine Roof Simulator. Functional relationships among variables were assessed, and confidence intervals were established for prediction of the resultant load vector parameters. Resultant load measurements were taken on five instrumented shields on an active longwall face in Colorado. Results were analyzed and found to be consistent with shield mechanics and anticipated roof behavior. Benefits to be derived from this research, future efforts, and long-range goals are discussed.

RI 9028. Recovery of Fluorite and Byproducts From Fish Creek Deposit, Eureka County, NV, by F. W. Benn, D. G. Foot, Jr., and J. L. Huiatt. 1986. 13 pp. 13 figs. The Bureau of Mines investigated flotation methods for recovering fluorite and byproducts from two samples of the Fish Creek deposit in Eureka County, NV. The preferred method for treating a fluorite-beryllium sample included (1) fluorite rougher and cleaner flotation, (2) desliming at 20 μm, (3) muscovite flotation, (4) silicate flotation, (5) sodium hypochlorite wash of silicate concentrate, and (6) beryllium rougher and cleaner flotation from the silicate concentrate. Laboratory results showed that over 94 pct of the fluorite was recovered in a recleaner concentrate containing 98 pct CaF_2. Beryllium flotation produced concentrates containing in excess of 5 pct BeO with recoveries over 70 pct. The preferred method used for a fluorite-mica sample consisted of (1) fluorite rougher and cleaner flotation, (2) desliming at 20 μm, and (3) mica flotation using an anionic-cationic collector system. Laboratory results showed that 84 pct of the fluorite was recovered in a recleaner concentrate containing 96 pct CaF_2. Mica flotation produced a concentrate containing 95 pct mica at 85-pct recovery.

RI 9029. Waveform Analysis of Electric Furnace Arcs as a Diagnostic Tool, by Thomas L. Ochs, Alan D. Hartman, and Stephen L. Witkowski. 1986. 19 pp. 14 figs. The Bureau of Mines is investigating the fundamental behavior of electric arcs in electric-furnace operations. The electric arc is a poorly understood phenomenon. If the arc in a steelmaking furnace can be more carefully controlled, it should be possible to increase heat transfer to the melt, reducing both electrical and acoustical noise. As a first step toward a better understanding of the arc, voltage and current signals from operating furnaces

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were analyzed. The results of the initial analysis show that instrumentation used in monitoring and controlling furnaces, such as meters and strip-chart recorders, gives incomplete or erroneous information to the operator and leads to less than optimal control. Advanced instrumentation and analysis techniques, such as the waveform analysis used in these investigations, can improve the understanding of operation and the control of electric furnaces. This report describes the instrumentation and the numerical analysis methods used and compares these methods with standard metering and recording techniques.

INFORMATION CIRCULAR

IC 9078. Surface and Underground Coal Mine Equipment Population, 1982, by Michael G. Pojar. 1986. 25 pp. 3 figs. This Bureau of Mines report estimates the population of the principal types of machinery in use by the coal mining industry during 1982 in surface and underground mines. Estimates were arrived at using 1976 coal equipment population estimates as baseline data with modifications made for new mine development, expansion, and closure occurring during 1976–82. Estimates were broken down into 3 regions that included all 26 coal-producing States. Modifications made to the baseline data were computed using (1) actual equipment information when available and (2) equipment information hypothesized from representative generic mine models, which were predicated on mine size and mine method. Roughly half of the equipment fleet at new or expanding coal operations was known; the remainder was hypothesized. The mine models used to generate equipment information are included in this report, along with the hypothesized equipment use data. The equations and various factors used to determine the equipment adjustments for mine closings, new mine openings, and small coal mine operations are also identified.

PREPRINTS FROM MINERALS YEARBOOK, 1985

These preprints are chapters from Minerals Yearbook, 1985. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

Asbestos, by Robert L. Virta. 7 pp.
Diatomite, by A. C. Meisinger. 3 pp.
Feldspar, Nepheline Syenite, and Aplite, by Michael J. Potter. 8 pp.
Fluorspar, by Lawrence Pelham. 10 pp.
Lithium, by James P. Searls. 7 pp.
Magnesium, by Deborah A. Kramer. 8 pp.
Magnesium Compounds, by Deborah A. Kramer. 7 pp.
The Mineral Industry of Liberia, by Ben A. Kornhauser. 5 pp.
Nitrogen, by Charles L. Davis. 7 pp.
Nonfuel Minerals Survey Methods, by Staff, Office of Statistical Standards. 5 pp. 1 fig.
Perlite, by A. C. Meisinger. 3 pp.
Phosphate Rock, by William F. Stowasser. 18 pp.
Potash, by James P. Searls. 12 pp.
Pumice and Pumicite, by A. C. Meisinger. 4 pp.
Sodium Compounds, by Dennis S. Kostick. 8 pp.
Thorium, by James B. Hedrick. 8 pp.

MINERAL INDUSTRY SURVEYS

Mineral Industry Surveys dealing with various commodities will be forwarded regularly if application stating in detail the need for certain reports is made to—

Branch of Editorial Services
Bureau of Mines
U.S. Department of the Interior
4900 LaSalle Rd.
Avondale, MD 20782

Some of these reports are issued weekly, monthly, quarterly, or annually. The following annual reports were issued during August.

Industrial Minerals Supply/Demand Data, 1974–1984 (Industrial Minerals, Annual). 85 pp. (PB 86–217353. $75, domestic; $150, foreign.)
Ferrous Metals, Supply/Demand Data, 1974–1984 (Ferrous Metals, Annual). 29 pp. (PB 86–217338. $75, domestic; $150, foreign.)
Nonferrous Metals Supply/Demand Data (Nonferrous Metals, Annual). 64 pp. (PB 86–217346. $75, domestic; $150, foreign.)

Reports including a number prefixed with PB are also available for purchase on 5½-inch magnetic floppy disk from—

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NOTE.—The three reports listed above may be purchased in a 3-disk set for $175, domestic; $350, foreign.

III. Open File Reports—NTIS

An open file report is an unpublished Bureau of Mines report that has been made available as reference material. Any open file report may be inspected during working hours at the locations indicated but may not be removed, except that the Natural Resources Library, U.S. Department of the Interior, Washington, DC 20240, can usually supply copies on interlibrary loan. For further information, contact the library, 202–343–5815.

If a number prefixed with PB is given, the report may be purchased by check or money order payable to the National Technical Information Service, charged to a deposit account at NTIS, or charged on a VISA, MasterCard, or American Express credit card. Address requests to—

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In the open file listings that follow, the symbols indicate facilities where reports are available for inspection. (See list for key symbols.)

AD/MDA	**Assistant Director—Mineral Data Analysis, USBM, Washington, DC.**
AD/MI	**Assistant Director—Minerals Information, USBM, Washington, DC.**
AD/MMR	**Assistant Director—Minerals and Materials Research, USBM, Washington, DC.**
AD/MR	**Assistant Director—Mining Research, USBM, Washington, DC.**
AFOC/A	**Alaska Field Operations Center, USBM, Anchorage, AK.**
AFOC/F	**Alaska Field Operations Center, USBM, Fairbanks, AK.**
AFOC/J	**Alaska Field Operations Center, USBM, Juneau, AK.**
ALRC	**Albany Research Center, USBM, Albany, OR.**
AVRC	**Avondale Research Center, USBM, Avondale, MD.**
DOI	**U.S. Department of the Interior.**
DRC	**Denver Research Center, USBM, Denver, CO.**

IFOC	**Intermountain Field Operations Center, USBM, Denver, Co.**
LIB	**Natural Resources Library, DOI, Washington, DC.**
MSHA	**Mine Safety and Health Administration, Arlington, VA.**
NMH&SA	**National Mine Health and Safety Academy, Beckley, WV.**
OSM	**Office of Surface Mining Library, DOI, Washington, DC.**
PRC/B	**Pittsburgh Research Center (Bruceton), USBM, Pittsburgh, PA.**
RERC	**Reno Research Center, USBM, Reno, NV.**
RORC	**Rolla Research Center, USBM, Rolla, MO.**
SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 9–86. Development of an Integrated System of Monitoring for the Detection of Imminent Subsidence, by Swapan Bhattacharya and Mandan M. Singh. Oct. 1985. 213 pp. 64 figs. Numerous instances of surface subsidence resulting from shallow, abandoned mine workings have been reported over a large portion of the anthracite coal region of northeastern Pennsylvania. This study presents a methodology for identifying sites within the anthracite region that have the potential for imminent subsidence, and proposes an integrated monitoring plan capable of detecting incipient subsidence prior to its surface manifestations. The site screening methodology is based on the premise that the monitoring sites should be located in areas characterized by high subsidence risk. A technique for assigning subsidence risks is presented. The integrated monitoring plan proposed involves the use of two surface geophysical methods (ground penetrating radar and electromagnetics) in combination with in situ displacement sensors. This selection is performed by progressive elimination of over 30 viable instrument alternatives. The selected instrumentation systems are fully described along with a conceptual plan for utilizing these methods in six selected monitoring sites within the study region. Finally, recommendations for the field testing and evaluation of the candidate instrument systems are provided. Research was done under contract J0134022 by Engineers International, Inc. Available for reference at AD/MR, LIB, OSM, PRC/B, and TCRC. Copies of this report will not be available for purchase.

OFR 73–86. Research To Determine the Feasibility of Utilizing Employee Assistance Programs for the Mining Industry—Final Report, by Paul S. Goodman. Jan. 1986. 234 pp. 5 figs. This report examines the feasibility of employee assistance plans for the coal industry. Three issues are examined in detail. First, the prevalence of off-the-job factors such as alcoholism, drug abuse, and marital problems are examined in a sample of miners from the eastern, midwestern, and western underground coalfields. Then data were presented that examined the link between these off-the-job factors and behaviors critical to the mines such as absenteeism and turnover. Lastly, the effectiveness of the major employee assistance program in underground coal mining—the HELP Program—was examined. The report contains recommendations on whether coal mining companies should implement these programs and how these programs should be designed. Research was done under contract J0100069 at Carnegie-Mellon University. Available for reference at AD/MR, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–227089; paper copy price code A11. $22.95.

OFR 74–86. Psychophysical Investigations of Discomfort and Disability Glare From Underground Coal Mine Illumination Systems, by K. L. Whitehead, P. Lindahl, R. Vincent, and C. Crouch. Oct. 1983. 252 pp. 52 figs. A literature search was conducted to identify current light-control technology and hardware that may be applicable on underground lighting systems to minimize disability and discomfort glare. No research dealing specifically with mine lighting was found, but abstracts on research considered potentially applicable are included in the report. Information on several commercial light-control products for use in controlling glare are also included. Vision tests conducted on 137 mine personnel to determine their discomfort and disability glare sensitivity indicate their sensitivity to disability glare is about the same as the general population. Miners' sensitivity to discomfort glare is 40% greater coming off-shift than when going on-shift. Tests on currently available mine lighting hardware showed none were satisfactory with respect to glare potential. Reflectivity measurements showed the average reflectivity of mine surfaces were 4.2% for coal, 8.3% for the roof, and 4.0% for the floor. Research was done under contract J0308090 by Bituminous Coal Research, Inc. Available for reference at ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–226941; paper copy price code A12. $22.95.

OFR 75–86. Development of a Reduced-Noise Auger, Cutting Head, by Mark R. Pitt. Mar. 1983. 195 pp. 69 figs. Noise surveys conducted in underground coal mines have consistently indicated that auger mining machines subject the operator and helpers to excessive noise exposure. The machine cutting heads have been identified as the primary noise source. This report documents the research program conducted to (1) investigate the nature of the cutting head noise problem, (2) develop noise control concepts, (3) devise in-mine survivable techniques to implement the noise control concepts, and (4) build and demonstrate prototype reduced-noise auger miner cutting heads. The dynamic forces generated during coal cutting by the brittle fracture of coal are predominantly low frequency. The low-frequency (less than 1,500 Hz) structural response of the cutting head determines the noise radiated by the cutting head. The most feasible methods of reducing the cutting head low-frequency response are to increase both the structural stiffness and the low-frequency damping. A technique was devised to achieve these goals. The standard plate helix was replaced by a sand-filled hollow helix of triangular cross section, and the core diameter was increased with an attendant reduction in helix depth. Extended in-mine tests demonstrated the operational capability of the reduced-noise auger cutting heads. The simple noise control concepts are valid for all continuous miner cutting heads. The sand-filled hollow helix technique, which achieved a 10-dB(A) noise reduction for the auger, can be used on any helix-bearing cutting head. Research was done under contract H0188065 by Wyle Laboratories. Available for reference at ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–226933; paper copy price code A09. $16.95.

OFR 78–86. Belt Conveyor Maintenance Installation Procedures, by Svend Bue Rondum. Oct. 1982. 91 pp. 66 figs. This report includes a collection of data from mine companies and manufacturers derived from on-site visits as well as a mail survey. Analysis activity was directed at developing an understanding of currently used safety practices related to underground coal mine belt conveyors and formulating better safety practices. This activity led to the development of design criteria upon which both the hardware and the procedures manual were based. Hardware development consisted of the conceptualization of new and unique solutions to existing problems, followed by the successful design, fabrication, and in-mine testing of prototypes (saucer skid, armored level, controlled tensioning device, and turnbuckle tensioning wrench). On-site observations and in-depth discussions with all levels of mine personnel, together with information from equipment manufacturers, provided the necessary background for the conceptualization of this procedures manual. Research was done under contract J0215004 by Management Engineers Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Copies of this report will not be available for purchase.

OFR 83–86. Mine Hoist Electrical Systems Study. Volume I—Mine Hoist Electrical Systems Inspection Manual, by Joseph D. Cooper and Robert H. King. July 1985.

199 pp. 31 figs. This manual describes how to inspect and maintain mine hoist electrical systems. It includes daily, weekly, monthly, and annual checklists. Federal regulations pertaining to electrical inspection are reviewed. Inspection and maintenance of hoist drives, switchgear, sensing devices, and brake cars are described. Considerable information is provided on Lilly controllers. American National Standards Institute standards for mine elevator inspection are reviewed. Research was done under contract J0134006 by the Colorado School of Mines. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–235132; paper copy price code A09. $16.95.

MINERAL ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 40–86. Mineral Resource Assessment of The Badger Canyon-Antelope Creek Site-Specific Study Area, Boulder-Pioneer Wilderness Study Area, Blaine County, Idaho, by Samuel W. McNary. 1986. 30 pp. 6 figs. Western Field Operations Center, Spokane, WA.

MLA 53–86. Mineral Investigation of a Part of the Continental Divide Wilderness Study Area (NM–020–044), Catron County, New Mexico, by Robert H. Wood II. 1986. 29 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MLA 54–86. Mineral Investigation of a Part of the Table Top Mountains Wilderness Study Area (AZ–020–172), Pinal and Maricopa Counties, Arizona, by John R. McDonnell, Jr. 1986. 14 pp. 4 figs. Intermountain Field Operations Center, Denver, CO.

IV. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 94–86. Leaching Aluminum-Superalloy Melts With Hydrochloric and Sulfuric Acids, by G. B. Atkinson and L. J. Nicks. Conserv. & Recycl. v. 9, No. 2, 1986, pp. 197–209. The Bureau of Mines investigated a method for increasing the leaching rate of bulk superalloy scrap to facilitate recycling and recovery of critical metals such as Ni, Co, and Cr. Superalloys were melted with 20%, 30%, 40%, and 50% Al to form intermetallic compounds. The melts were easily crushed to a convenient particle size and leached rapidly with hydrochloric and sulfuric acid solutions. Leaching ½-in pieces of scrap IN–738 with excess 6*N* HCl at 95° C for 2 h resulted in only 0.5% dissolution, whereas leaching 10 g of minus 20 mesh 30% Al-70% IN–738 with excess 6*N* HCl at 95° C for 2 h achieved a 96.2% dissolution.

OP 95–86. Bauxite, by Luke Baumgardner. Ceram. Bull., v. 65, No. 5, 1986, pp. 729–730. This paper reviews the consumption of domestic and imported calcined refractory-grade bauxite by U.S. refractory industries during 1985. Prices, quantities, and principal sources of refractory bauxite imports are also discussed.

OP 96–86. Bureau's Information Helps Industry Make Decisions, by V. Anthony Cammarota, Jr. Am. Min. Congr. J., v. 72, No. 12, July 1986, p. 7. The objective of the Bureau of Mines' information program is briefly described, and the publications are listed through which minerals data are disseminated. The data are used by government and industry for planning capital investments, setting stockpile policy, and for working with other international statistical organizations.

OP 97–86. Bismuth Production, by J. F. Carlin, Jr. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 1 (A-Co), 1986, pp. 352–353. This article describes the byproduct nature of bismuth and its processing from copper and lead-based minerals into refined bismuth by the Betterton-Kroll and Betts electrolytic processes.

OP 98–86. Indium Production, by J. F. Carlin, Jr. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 3 (F-I), 1986, p. 2285. This article discusses the production of refined indium from zinc ores and from various other source materials.

OP 99–86. Mercury Production, by L. C. Carrico. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 4 (J-N), 1986, p. 2946. This article contains an overview of the mercury production process. Some of the topics addressed are mining, beneficiation, and a variety of recovery processes.

OP 100–86. The Mexico City Earthquakes. Mining Technology Applied to Rescue Efforts, by Harry Dobroski, Jr. Technotimes, June 1986, pp. 4, 13. On September 19, 1985, Mexico City was struck by a massive earthquake that measured 8.1 on the Richter scale. This was followed the next day by another quake registering 7.5. A team composed of personnel from the Bureau of Mines, the Office of Surface Mining, and the Mine Safety and Health Administration arrived in Mexico City on September 21, 1985, bringing with them a number of technologies developed for mining situations: (1) a miniature television camera borehole probe designed to investigate abandoned mines, (2) a seismic detection system designed to locate trapped miners, and (3) an expertise in explosives. This paper describes the television probe and seismic system that were directly and indirectly involved in several successful rescues.

OP 101–86. Near Surface Elemental Concentration Gradients in Annealed 304 Stainless Steel as Determined by Analytical Electron Microscopy, by P. M. Fabis and B. S. Covino, Jr. Oxid. Met., v. 25, Nos. 5–6, 1986, pp. 397–407. Elemental concentration profiles in the near surface region of 304 stainless steel resulting from hot-band annealing have been investigated with scanning transmission electron microscopy-energy dispersive X-ray spectrometry. A severe Cr depletion in the top 100 nm of the steel surface was observed, and a Ni enrichment was present at depths less than 1 μm. The maximum Cr depletion depth, which was approximated by an error function relationship, was in excellent agreement with the Cr depletion depth maximum determined experimentally. The oxide-alloy interfacial Cr concentration projected from the parabolic depletion profile of the 304 stainless steel at depths greater than 400 nm was also in reasonable agreement with the calculated value. The oxide-metal interfacial (within 50 nm) Cr concentration determined experimentally was, however, substantially lower than the calculated values. Doping effects on the oxide defect structure were proposed to enhance the diffusive flux from the alloy surface region and to contribute to nonparabolic growth effects of the Cr depletion profile in this region during short-term annealing.

OP 102–86. Beryllium Production, by K. L. Harris. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 1 (A-Co), 1986, pp. 298-299. This article describes the fluoride and sulfate processes of extracting beryllium hydroxide from beryl.

OP 103–86. Overview of Rare-Earth Reserves and Worldwide Availability, by James B. Hedrick. Paper in Proceedings of the Eighth International Workshop on Rare-Earth Magnets and Their Applications and the Fourth

International Symposium on Magnetic Anisotropy and Coercivity in Rare Earth-Transition Metal Alloys, Dayton, OH, May 6–9, 1985, ed. by Karl J. Strnat. Univ. of Dayton, OH, May 1985, pp. 365–376. This paper examines the growth in the use of rare-earth permanent magnets and its dependence on the availability of many of the lanthanide elements and yttrium (rare earths). Reserves and resources of rare earths, located throughout the world, are large relative to demand. Theoretical rare-earth supplies, based on the average rare-earth contents of producing reserves and theoretical processing and separation capabilities, are calculated to assess future rare-earth availability.

OP 104–86. Palladium Production, by J. H. Jolly. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 5 (O-Q), 1986, p. 3381. This article briefly discusses the extraction of palladium and other platinum-group metals from nickel-copper and copper ores.

OP 105–86. Plutonium Production, by J. H. Jolly. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 5 (O-Q), 1986, pp. 3582–3583. This article describes the extraction process used to recover plutonium from irradiated uranium fuels used in power reactors.

OP 106–86. Potassium Production, by J. L. W. Jolly. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 5 (O-Q), 1986, p. 3859. This article discusses the production of potassium in the United States by the thermochemical distillation of potassium chloride with sodium.

OP 107–86. Thorium Production, by W. S. Kirk and R. V. Sondermayer. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 7 (T-Z), 1986, p. 4991. This article describes the chemical processes involved in the extraction of thorium from monazite, a byproduct of the mining and processing of mineral sands.

OP 108–86. Development and Testing of a Water-Jet-Assisted Longwall Shearer, by Wilhelm J. Kogelmann and Edward D. Thimons. Paper in Proceedings of Longwall USA Conference, Pittsburgh, PA, June 24–26, 1986, pp. 277–304. This paper describes the design, manufacture, and testing of a 3,000- to 10,000-psi water-jet-assisted longwall shearer that can be retrofitted to existing standard machines. This shearer is the first of its kind to have a water jet associated with each bit, and it also features a phased water delivery system designed to minimize water usage.

OP 109–86. Soda Ash, by D. S. Kostick. Min. Eng., v. 38, No. 5, May 1986, pp. 365–366. This paper describes the changes in the use and consumption of soda ash owing to substitutes for this material in the glass container industry. Also discussed are the repercussions of corporate acquisitions and divestitures among U.S. soda ash companies.

OP 110–86. Gold, by J. M. Lucas. Min. Eng., v. 38, No. 5, May 1986, pp. 332–333. Despite the year's lower gold prices, exploration for gold and the development of new mines worldwide continued to expand during 1985. U.S. developments were highlighted by Nevada's continued dominance as both a gold producer and the focal point for gold exploration and mine development. Domestic gold consumption and gold trading activity on the nation's commodity exchanges declined from 1984 levels. Net imports of gold rose substantially during the year. Foreign gold developments included increased exploration, mine development, and production in many countries, especially Canada and Australia. The Republic of South Africa was again the world's largest producer with about 46% of the world total of over 47 million oz. World gold consumption increased over that of 1984. Gold mine production and gold consumption in the United States and the rest of the world was expected to increase through the end of the century.

OP 111–86. Production and Use of Precious Metals in 1985, by J. M. Lucas, R. G. Reese, Jr., and J. R. Loebenstein. Precious Met., v. 10, No. 6, June 1986, pp. 1–3. This article is an annual review of the world supply and demand for gold, silver, and platinum-group metals. It includes two tables that show general statistics on precious metals plus a breakdown of the usage of precious metals.

OP 112–86. Titanium Minerals, by L. E. Lynd. Min. Eng., v. 38, No. 5, pp. 368–369. Consumption and production of titanium concentrates, titanium dioxide (TiO_2) pigments, and titanium metal in 1985 are reviewed. Highlights include record high consumption of TiO_2 pigments, and plans for new or increased capacity for production of concentrates to meet the high TiO_2 demand.

OP 113–86. Electrochemistry of the Chalcocite-Xanthate System, by C. S. O'Dell, G. W. Walker, and P. E. Richardson. J. Appl. Electrochem., v. 16, No. 4, 1986, pp. 544–554. This paper describes the interactions between chalcocite and ethylxanthate when examined in an electrochemical-microflotation cell containing a particle-bed working electrode. Cyclic voltammetry has shown the formation of a chemisorbed product commencing at –0.5V versus saturated calomel electrode, with a bulk oxidation product, possibly cuprous xanthate, forming above –0.23V. Relating the charge passed on a potentiostated mineral bed after addition of xanthate to spectrophotometric changes in xanthate concentration suggested the presence of a fast chemical reaction and a charge transfer reaction. The strong correlation between flotation response and potential indicates that chemisorption of ethylxanthate produces a layer sufficiently hydrophobic for chalcocite flotation.

OP 114–86. Calcium Production, by J. W. Pressler. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 1 (A-Co), 1986, pp. 481–482. This article describes the aluminothermal vacuum process of extracting calcium from high-purity limestone, and the uses of calcium in the refining and extraction of other minerals.

OP 115–86. Cadmium Production, by R. G. Reese. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 1 (A-Co), 1986, pp. 467–468. This article discusses the process required to produce cadmium from fume and dusts collected from the pyrometallurgical processing of zinc-bearing ores or from the cadmium-enriched residues of certain electrolytic zinc operations.

OP 116–86. Silver, by R. G. Reese. Min. Eng., v. 38, No. 5, May 1986, pp. 333–334. This article is a review of the U.S. and world silver markets during 1985. Preliminary supply and demand data are presented, along with an overview of significant U.S. industry developments and the outlook for 1986.

OP 117–86. Cobalt Resources, by S. F. Sibley and W. S. Kirk. Sec. in Encyclopedia of Materials and Science Engineering, ed. by Michael B. Bever. Pergamon, Elmsford, NY, v. 1 (A-Co), 1986, pp. 698–701. This article discusses the commercial applications of cobalt and the location of significant deposits around the world.

OP 118–86. Potential of Spent Catalysts as a Source of Critical Metals, by R. E. Siemens, B. W. Jong, and J. H. Russell. Conserv. & Recycl., v. 9, No. 2, 1986, pp. 189–196. Characterization and hydrometallurgical research was conducted by the Bureau of Mines to devise procedures for recovery of metals such as Co, Ni, V, W, Mo, Cr, Fe, Cu, or Zn from waste catalysts. The research effort was concentrated on recovery of metals from spent hydroprocessing, hydrogenation, and high-temperature shift catalysts. Results showed that 73% to 99% of the contained critical metals were extracted by a variety of processing approaches, including anhydrous chlorination, ammoniacal, acid, or caustic leaching, and Na_2CO_3 roasting followed by water leaching.

OP 119–86. Longwall Shearer Performance Using Water-Jet-Assisted Cutting, by C. D. Taylor, P. D. Kovscek, F. N. Kissell, and E. D. Thimons. Paper in Proceedings of Longwall USA Conference, Pittsburgh, PA, June 24–26, 1986, pp. 233–256. The U.S. Bureau of Mines equipped a longwall shearer with a water-jet-assisted mechanical cutting system to determine the effect of the high-pressure sprays on machine performance, airborne dust levels generated, and size of particulates formed. Testing was conducted on a simulated coal block (coalcrete) while cutting at a water pressure of 190 psi and at water-jet-assisted pressures ranging from 1,000 to 6,000 psi. The shearer motor energy used by the shearer during cutting coalcrete was determined for each cutting condition. Results indicate that the motor energy required by the shearer for each ton of material cut did not vary significantly as the water pressure was increased. Results of dust measurements recorded near the cutting drum indicate that at water pressures above 3,000 psi, dust reductions up to 85 pct were achieved compared with cutting with conventional sprays. Analysis of the particulate size distribution formed during cutting showed that increasing the water pressure resulted in increased median particle size. In light of these results, various mechanisms for water-jet-assisted cutting are discussed.

OP 120–86. 1984 Crushed Stone Data, by Valentin V. Tepordei. Rock Prod., v. 88, No. 9, Sept. 1985, pp. 55–58. The data is in the form of a detailed map showing every county in the United States containing a crushed stone quarry. Statistics on crushed stone production by State are also included.

OP 121–86. Bureau of Mines Revises System, by Valentin V. Tepordei. Rock Prod., v. 88, No. 12, Dec. 1985, pp. 56–57, 84. This paper describes a new system for reporting aggregate production information by grouping adjacent counties into districts. This method of gathering information is expected to increase the number of producers in each reporting area and eliminate the confidentiality problem when statistics are revealed on a company-by-company basis.

OP 122–86. Biological Catalysis of the Oxidation of Iron(II) in Acid Mine Waters in a Sequencing Batch Suspended Film Reactor, by T. L. Theis, L. H. Ketchum, Jr., and W. H. Engelmann. Trans. Soc. Min. Eng. AIME, v. 276, 1984, pp. 1891–1899. The use of a suspended growth system of *Thiobacillus ferrooxidans* attached in a film to individual particles of bentonite and operated as a sequencing batch reactor is shown to be a practical way of oxidizing ferrous iron in acid mine drainage. This component, followed by limestone neutralization, is both a technically and economically feasible approach to treating these wastewaters, compared with existing and other proposed methods. The advantages, in addition to less expense, are greater safety, acceptable treatment at a lower pH, lower solids buildup, less danger of overtreatment, and greater flexibility in operational characteristics. In this paper, data on the continuous bench-scale operation of the system under a variety of conditions show sustained levels of oxidation in excess of 98%. Capital and operating costs are projected to be \$80/1,000 m^3 (\$80 per 35,000 cu ft) of wastewater.

OP 123–86. The Worldwide Availability of Gold, by P. R. Thomas, E. H. Boyle, Jr., and J. M. Lucas. Nat. Resour. Forum, v. 10, No. 1, Feb. 1986, pp. 39–50. This paper summarizes Bureau of Mines research relating to the state of the world gold industry. The authors discuss the world gold industry structure, resources, production, and the long-term cost and availability of primary gold production from producing mines and developing deposits in 13 market economy countries (MEC's). Total recoverable gold available from the evaluated mines and deposits is estimated at 819 million troy ounces. The Republic of South Africa is estimated to account for 87% of total recoverable gold. The United States and Canada account for 4% and 4.5% of the total, respectively. Eighty-three percent of total recoverable gold is available at a constant 1984 break-even price of \$400 per ounce. South Africa accounts for 90% of the gold available at \$400 per ounce or less. Gold resources in the Soviet Union and China are discussed but not evaluated. South Africa should remain the largest world producer until the year 2000, and annual MEC output in the year 2000 should not be significantly different from current output, given constant 1984 gold prices of more than \$300 per ounce.

OP 124–86. Productivity, Safety, and Environment—A Coordinated Approach for Improving Coal Mining Technology, by Lewis V. Wade and James J. Olson. Paper in Proceedings of the Illinois Mining Institute Annual Meeting, Springfield, IL, Oct. 31–Nov. 1, 1985, pp. 21–43. As part of its mission to help assure that the Nation has an adequate supply of minerals, the Bureau of Mines is conducting research to remove the obstacles to development of new, more productive mining methods. At the same time, these new technologies must assure the safety and health of the worker and allow extraction of the coal within the restrictions of existing and projected environmental regulations. The research program at the Bureau's Twin Cities Research Center (TCRC) in Minneapolis, MN, is structured to address all three aspects: productivity, health and safety, and environment. This paper summarizes current status of several TCRC projects that have particular relevance to the Illinois coal mining district.

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BULLETINS

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B 684. Bureau of Mines Research on Recycling Scrapped Automobiles, by K. C. Dean, J. W. Sterner, M. B. Shirts, and L. J. Froisland. 1986. 46 pp. 31 figs. Discarded automobiles represent the greatest single resource of reusable metals, plastics, and rubber in the United States. This report presents results of Bureau of Mines research, conducted from 1965 to 1983, on separating and recovering useful materials from the scrapped hulks, using old and new metallurgical techniques combined with standard scrapyard methods. The Bureau determined the materials composition of three composite cars designated as circa 1960, mid-1970's and early 1980's, and used these cars to study smokeless incineration and hand-sorting techniques. In studies on treating rejects from automobile shredders, the Bureau designed a process that included air classification, water elutriation, magnetic separation, handpicking, and heavy-medium separation, and also investigated cryogenics and liquation. Complete recovery of copper and other metals was economically made by hand and tool dismantling, leaching, or selective melting of starters and generators. Techniques are also discussed for plastic recovery and waste tire treatment. GPO Stock No. 024–004–02166–7. $2.75.

B 686. The Citrate Process for Flue Gas Desulfurization, by W. I. Nissen, L. Crocker, L. L. Oden, and others. 1986. 69 pp. 47 figs. As part of its program to provide technology for reducing undesirable environmental impacts of mineral processing operations, the Bureau of Mines developed the citrate process for desulfurizing industrial stack gases that contain from 0.1 to 2 vol pct SO_2. In this regenerable flue gas desulfurization process, SO_2 is absorbed from cleaned and cooled industrial flue gas with a citric acid-sodium citrate solution. The absorbed SO_2 is subsequently reacted with H_2S to precipitate marketable elemental sulfur and regenerate the solution for recycle. Laboratory investigations of process parameters provided information for designing larger scale continuous operations. Information gathered from operation of two pilot plants, one at a copper smelter and one at a lead smelter, confirmed the laboratory results. Data were obtained for design and construction of a commercial-sized demonstration plant at the George F. Weaton Power Station, Monaca, PA. A preliminary operation of the plant was demonstrated under a cost-sharing Bureau-industry contract. This bulletin describes the citrate process and gives results of the laboratory, pilot plant, and demonstration plant studies, as well as corrosion investigations. GPO Stock No. 024–004–02169–1. $3.75.

INFORMATION CIRCULAR

IC 9081. Thermodynamic Properties of Selected Metal Sulfates and Their Hydrates, by Carroll W. DeKock. 1986. 59 pp. Thermodynamic data for selected metal sulfates were critically evaluated and compiled as part of the Bureau of Mines program to provide a scientific base for use in developing new technology and predicting the feasibility of new processes. Values for Cp°, S°, $H^\circ - H^\circ_{298}$, $-(G^\circ - H^\circ_{298})/T$, ΔHf°, ΔGf°, and log Kf as functions of temperature are given in tabular form. Thermodynamic data were compiled for Ag_2SO_4, $Al_2(SO_4)_3$, $Al_2(SO_4)_3 \cdot 6H_2O$, $BaSO_4$, $BeSO_4$, $BeSO_4 \cdot 2H_2O$, $BeSO_4 \cdot 4H_2O$, $CaSO_4$, $CaSO_4 \cdot 1/2H_2O$, $CaSO_4 \cdot 2H_2O$, $CdSO_4$, $CdSO_4 \cdot H_2O$, $CdSO_4 \cdot 8/3H_2O$, $2CdO \cdot CdSO_4$, Cs_2SO_4, $In_2(SO_4)_3$, K_2SO_4, $KAl(SO_4)_2$, $KAl(SO_4)_2 \cdot 12H_2O$, Li_2SO_4, $Li_2SO_4 \cdot H_2O$, $MgSO_4$, $MgSO_4 \cdot H_2O$, $MgSO_4 \cdot 2H_2O$, $MgSO_4 \cdot 4H_2O$, $MgSO_4 \cdot 6H_2O$, $MgSO_4 \cdot 7H_2O$, Na_2SO_4, $Na_2SO_4 \cdot 7H_2O$, $Na_2SO_4 \cdot 10H_2O$, $(NH_4)_2SO_4$, $NH_4Al(SO_4)_2$, $NH_4Al(SO_4)_2 \cdot 12H_2O$, $PbSO_4$, Rb_2SO_4, Tl_2SO_4, and $Zr(SO_4)_2$. GPO Stock No. 024–004–02168–3. $3.25.

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REPORT OF INVESTIGATIONS

RI 9035. Measurement of Dielectric Properties of Minerals at Microwave Frequencies, by W. E. Webb and R. H. Church. 1986. 8 pp. 7 figs. This report describes a method the Bureau of Mines devised for measuring the dielectric constant and loss tangent of low-loss minerals at microwave frequencies. Determination of these properties makes it possible to predict the effects of using microwave heating in potential processing applications. The method uses a test cell and a radio-frequency impedance analyzer with automated data acquisition and analysis. In this initial phase of microwave heating research, the Bureau measured dielectric constants and loss tangents at frequencies between 100 MHz and 1 GHz. The objective was to establish a reliable data base for use in predicting the effects of microwave heating on minerals. Comparison with previously measured data showed the Bureau's measurement method to be accurate to within ±3 pct. This report describes the method and discusses the preliminary results of the Bureau's investigations. Typical comparative data are included. This report is based upon work done under an agreement between the University of Alabama and the Bureau of Mines.

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INFORMATION CIRCULARS

IC 9084. Potash Availability—Market Economy Countries. A Minerals Availability Appraisal, by D. E. Sullivan and N. Michael. 1986. 32 pp. 23 figs. The Bureau of Mines investigated the availability of potash from 68 mines and deposits in 12 market economy countries (MEC's) containing, at the demonstrated resource level, approximately 11.7 billion metric tons (mt) of potash in assay terms of contained K_2O as used by industry as a standard of comparison for the different forms of potash. These resources include almost 190 million mt in the United States, 9.63 billion mt in Canada, approximately 430 million mt in Western Europe (France, Federal Republic of Germany, Italy, Spain, and the United Kingdom), 1.24 billion mt in the Middle East (Israel and Jordan), and over 220 million mt in other countries (Brazil, Chile, and the Congo). This analysis has determined that future production of potash in MEC's will most likely continue to be from the large resources associated with producing operations in Canada. Based solely on the demonstrated resources included in this study, potash mining in the United States would decline while overseas production from MEC's can continue into the next century at near current production levels. However, timely development of new or inferred resources would offset any such decline. Producing mines in Canada have the resources to increase and maintain increased production well into the next century. For U.S. potash users, Canada is a long-term stable and secure source.

IC 9086. Tin Availability—Market Economy Countries. A Minerals Availability Appraisal, by D. I. Bleiwas, Andrew E. Sabin, and G. R. Peterson. 1986. 50 pp. 21 figs. The Bureau of Mines determined demonstrated tin resources and costs associated with tin production in order to evaluate the potential for tin production from 18 market economy countries. Data were collected from tin producers, in most cases during on-site visits. The analyses evaluated the relative economic and resource position of 146 mines, deposits, or regions in January 1984 dollars. The demonstrated resource of recoverable tin within the nations studied is approximately 2.8 million metric tons. Of this total, over 73 pct is recoverable from the Southeast Asian countries of Malaysia, Thailand, and Indonesia, which in 1983 accounted for almost 60 pct of the world's tin production. Brazil has joined the Southeast Asian countries as a major low-cost, high-volume supplier of tin and is likely to continue to expand its production. Given the 1984 market structure, over 60 pct of the tin in demonstrated resources was economically recoverable. Historically, the International Tin Council has helped maintain relatively stable tin prices through a buffer stock and sales quotas. In late 1985, exhaustion of buffer stock funds led to suspension of tin trading on the world's major tin metal exchanges.

IC 9092. Application of Employee Turnover Research Findings to the Mining Industry, by Robert H. Peters, 1986, 29 pp. 1 fig. Several significant problems associated with employee turnover among underground miners are described in this Bureau of Mines report. Although a vast amount of research has been conducted on turnover among employees in nonmining industries, there has never been an attempt to empirically investigate the causes of turnover among underground miners. This report presents the results of empirical research on employee turnover in other industries and describes and critiques the research methods that have been used to investigate turnover. Using the findings on employee turnover in other industries and known data about miners and the mining industry, a conceptual model of the factors that cause turnover among miners was generated. This model, which is expected to provide a basis for later empirical studies, is presented. Several recommendations for controlling miner turnover are also presented.

IC 9094. Cutter Roof Failure: An Overview of the Causes and Methods for Control, by John L. Hill III. 1986. 27 pp. 34 figs. The Bureau of Mines is conducting research on the causes and methods for control of cutter roof failure in underground coal mines. This hazardous ground control problem exposes miners to the danger of falling roof rock and frequently results in massive roof failure. This report outlines the probable causes of cutter roof failure, which are based on field investigations, numerical model analysis, and in-mine observations. Traditional methods of control are presented, as well as innovative methods based on mining concepts developed during earlier years of coal mining history. The report can be useful to a mine operator for assessing the causes of cutter roof failure on a site-by-site basis and for predicting the probability of its occurrence. A process is presented for selecting an optimum control method that includes both traditional and innovative control techniques for each of the various causes of cutter roof failure.

PREPRINTS FROM MINERALS YEARBOOK, 1985

These preprints are chapters from Minerals Yearbook, 1985. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

Bromine, by Phyllis A. Lyday. 8 pp.
Iodine, by Phyllis A. Lyday. 6 pp.
Mica, by Lawrence L. Davis. 9 pp.
The Mineral Industry of Iceland, by Richard H. Singleton. 6 pp.
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The Mineral Industry of Malta, by John R. Craynon and Roman V. Sondermayer. 4 pp.
Molybdenum, by John W. Blossom. 8 pp.
Nickel, by Peter G. Chamberlain. 16 pp. 2 figs.
Other Industrial Minerals, by Staff, Division of Industrial Minerals. 9 pp.
Peat, by Charles L. Davis. 7 pp. 1 fig.
Slag—Iron and Steel, by Donald P. Mickelsen. 12 pp.
Tin, by James F. Carlin, Jr. 12 pp.

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AFOC/A	**Alaska Field Operations Center, USBM, Anchorage, AK.**
AFOC/F	**Alaska Field Operations Center, USBM, Fairbanks, AK.**
AFOC/J	**Alaska Field Operations Center, USBM, Juneau, AK.**
ALRC	**Albany Research Center, USBM, Albany, OR.**
AVRC	**Avondale Research Center, USBM, Avondale, MD.**
DOI	**U.S. Department of the Interior.**
DRC	**Denver Research Center, USBM, Denver, CO.**
IFOC	**Intermountain Field Operations Center, USBM, Denver, CO.**
LIB	**Natural Resources Library, DOI, Washington, DC.**
MSHA	**Mine Safety and Health Administration, Arlington, VA.**
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PRC/B	**Pittsburgh Research Center (Bruceton), USBM, Pittsburgh, PA.**
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RORC	**Rolla Research Center, USBM, Rolla, MO.**
SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 46–86. Auto-Track Bridge Conveyor Train for Continuous Face Haulage, by D. D. Durrett and D. T. Atkinson. Feb. 1986. 225 pp. 126 figs. The auto-track bridge conveyor train (ABCT) is a continuous haulage system designed for underground coal mines. The ABCT is made up of identical "units," each of which consists of a wheeled mobile bridge carrier and a bridge conveyor. Microprocessors located on each carrier enable the entire train to follow precisely a predetermined course along the section's haulage route with minimal operator control requirements. Sensors determine each carrier's position with respect to a signal cable. This cable is automatically deployed on the mine floor as the system advances behind the continuous miner. This report summarizes system design efforts, prototype testing, and subsequent redesign and prototype modifications. Research was done under contract J0333913 by Foster-Miller, Inc. Availaole for reference at AD/MR, ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 86–239795; paper copy price code A11. $22.95.

OFR 76–86. South Africa and Critical Materials, by Staff, Division of Minerals Policy and Analysis. July 1986. 86 pp. 8 figs. In September 1985, the chairman of the Transportation, Aviation and Materials Subcommittee of the House of Representatives requested that the Director of the Bureau of Mines address the issue of South Africa and critical materials dependency in testimony before the subcommittee. Subsequent to the testimony, the Bureau has prepared a technical report focusing on the importance of South Africa and, in some cases, its neighboring countries as suppliers of six key materials: chromium, manganese, platinum-group metals, cobalt, gold, and vanadium. The report includes a qualitative analysis that examines the supply shortfall resulting from a potential disruption, options that are available for mitigating the impact and their likely effectiveness, and quantitative analyses that estimate the economic impacts in the chromium and manganese markets resulting from peacetime disruption scenarios specified by the subcommittee chairman. The concluding section treats the role and capabilities of the Bureau of Mines in dealing with mineral supply disruptions. Research was done by the Bureau of Mines Division of Minerals Policy and Analysis. Available for reference at AD/MDA, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–236601; paper copy price code A05. $11.95.

OFR 84–86. Development of Engineering and Cost Data for Foreign Magnesium Properties, by George E. Aiken. Sept. 1984. 32 pp. 3 figs. This report summarizes the objectives and methodology of a contract to obtain and record data on some 23 potential or operating foreign sited plants producing magnesia or magnesium products. These foreign plants were visited at location once they were established as significant factors in world magnesium markets. Individual resources or reserves of raw materials were established or estimated, and technical descriptions of existing or conceptual operations are described. Capital and operating costs were estimated for all properties profiled in the study. Research was done under contract J0225016 by Raymond Kaiser Engineers, Inc. Available for reference at AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 86–236700; paper copy price code A03. $9.95.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 52–86. Gold, Silver, and Tungsten Resources of the Courthouse Vein System, Sangre de Cristo Wilderness Study Area, Alamosa and Huerfano Counties, Colorado, by David C. Scott, 1986. 28 pp. 9 figs. Intermountain Field Operations Center, Denver, CO.

MLA 57–86. Mineral Investigation of a Part of the New Water Mountains Wilderness Study Area (AZ–020–125), La Paz County, Arizona, by Michael E. Lane. 1986. 25 pp. 16 figs. Intermountain Field Operations Center, Denver, CO.

MINERAL INSTITUTES REPORTS

The mineral institutes program operates under Public Law 98–409 and under title III of Public Law 95–87. It is designed to improve the quality of mineral engineering research and education through support for research in mining, metallurgical processing, and related mineral sciences. The Bureau of Mines supports this research through annual allotment grants, matched by non-Federal funds, to mineral institutes at 31 universities throughout the United States, and by research grants to these institutions to address specific mining and processing problem areas.

The following reports describe research conducted under research grants. Individual copies may be available from the authors of the papers at the university cited. Copies of these reports are NOT available from the Bureau of Mines.

MIR 1–86. Yield Pillar Simulation Using Physical Modeling, by Dwayne C. Kicker and Duk-Won Park. Ch. 35 in Rock Mechanics: Key to Energy Production, ed. by Howard L. Hartman (Proc. 27th U.S. Symposium on Rock Mechanics, Tuscaloosa, AL, June 23–25, 1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 224–231. As the use of longwall mining increases in the United States, there is a need to better understand the stress redistributions indicative of this method. To control high stress concentrations, the yield pillar concept has been developed. A physical longwall mine model has been designed to study the effect of yield pillars in deep mining. The model includes sensitive stress measuring devices, a new

excavating technique, and a new model material. This study includes the use of both regular and yield pillar systems and has successfully simulated the mode of stress change in chain pillars. The research was done under grant G1125151–0101 at the University of Alabama.

MIR 2–86. Stability Analysis of Entries in a Deep Coal Mine Using Finite Element Method, by Duk-Won Park and Nadim F. Ash. Min. Sci. and Technol., v. 3, 1985, pp. 11–20. Strain-softening behavior of rock and coal layers around a coal mine opening was simulated using a quasi-elastic approach that accounts for residual strength after failure. This simulation was achieved in such a way that material values were modified after each run, according to stress distribution, until the simulation reached an equilibrium condition. MSC/NASTRAN / Finite Element Method program was used for the simulation. The effect of a yield system was analyzed in comparison with a regular pillar system. The results agreed with the field measurement in terms of stress distribution and floor heave. The research was done under grant G1125151–0101 at the University of Alabama.

MIR 3–86. Physical Model Study of a Longwall Mine, by Duk-Won Park and Dwayne C. Kicker. Min. Sci. and Technol., v. 3, 1985, pp. 51–61. In this study, a new physical model for longwall mining is developed combining features of the "sandbox" model with a new concept for excavation of mine openings using a special tool. The model is used to examine stress distributions around a longwall face in chain pillars, as well as in the panel. Reproducible results are obtained, which enable a successful simulation by the model of the mode of stress changes in chain pillars, and measurement of the development of panel front abutment. The research was done under grant G112515–0101 at the University of Alabama.

IV. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 125–86. Noise-Controlled Longwall Shearer Cutting Head, by William W. Aljoe and Mark R. Pettitt. Paper in Progress in Noise Control, Volume I, ed. by Robert Lotz (Proc. 1986 International Conference on Noise Control Engineering, Cambridge, MA, July 21–23, 1986). Noise Control Found., Poughkeepsie, NY, 1986, pp. 321–326. A new noise-controlled longwall shearer cutting head is described, highlighting the design steps taken to reduce noise by increasing the stiffness of the helixes and face ring, and by the damping of the core. Test results include measurement of overall noise levels as well as at the lead-drum operator position, the reaction of miners to this new head, and its general performance in cutting coal.

OP 126–86. Behavioral Aspects of Roof/Rib Injuries—Implications for Training Utilizing Stereoscopic Photography, by Edward A. Barrett. Paper in Proceedings of Fifth Conference on Ground Control in Mining, Morgantown, WV, June 11–13, 1986, ed. by A. Wahab Khair and Syd S. Peng. WV Univ., 1986, pp. 213–220. This study is a report of experimental research on the use of stereoscopic (3-D) slides for presenting visual cues associated with hazardous roof and rib conditions. Compared with conventional slides, 3-D slides provide for significantly greater hazard recognition among both experienced and inexperienced miners. Details such as the presence of cracks and gaps in the surrounding rock are more accurately and realistically perceived. Reaction to the 3-D slides by the mine training community has been positive, and it has been noted that they also stimulate trainees' overall interest.

OP 127–86. Noise of Chain Conveyors in Mining, by J. A. Burks and W. J. Peterson. Paper in Progress in Noise Control, Volume I, ed. by Robert Lotz (Proc. 1986 International Conference on Noise Control Engineering, Cambridge, MA, July 21–23, 1986). Noise Control Found., Poughkeepsie, NY, 1986, pp. 327–332. This paper describes research by the Bureau of Mines to identify and control the excessive noise of chain conveyors. The major noise source is the impact of the chain on the tail roller on the upper and lower decks. Abatement technology has emerged in the form of constrained layer damping for the conveyor decks, vibration isolation, and a reduction in structural discontinuities. A newly constructed conveyor test bed assembly was used to create and control a wide range of test conditions not possible in the operating environment of an underground mine. The effects of chain speed, the shape of the discontinuity, the type of chain, and chain tension on the noise level were investigated. It is anticipated that a model based on single impact analysis will be developed to predict noise level as a function of the various parameters under study. The advantages of a variable-speed conveyor were also explored.

OP 128–86. Changing Patterns in U.S. Nickel Consumption, by Peter G. Chamberlain. Paper in Industrial Applications of Nickel, Volume II, ed. by E. Özberk and S. W. Marcuson (Proc. of 25th Annual Conference of Metallurgists—1986, Toronto, Ontario, Canada, Aug. 17–20, 1986). Can. Inst. Min. and Metall., Montreal, Quebec, Canada, 1986, pp. 193–215. Consumption trends in the U.S. nickel industry during the 1970's and 1980's are discussed, with a special emphasis on their impact on future predictions.

OP 129–86. Environmental Effects on Metallic Corrosion Products Formed in Short-Term Atmospheric Exposures, by D. R. Flinn, S. D. Cramer, J. P. Carter, D. M. Hurwitz, and P. J. Linstrom. Ch. 7 in Materials Degradation Caused by Acid Rain (ACS Symposium Series No. 318), ed. by Robert Baboian. Am. Chem. Soc., 1986, pp. 119–151. The Bureau of Mines has measured short- and long-term atmospheric corrosion damage on five metals and two metal-coated steel products at four sites in the east and northeast United States as part of the National Acid Precipitation Assessment Program to evaluate the effects of acid deposition on materials. The composition of the corrosion product on carbon steel, weathering steel, copper, zinc, and galvanized steel is relatively unchanged in 1- and 3-month exposures over a wide variety of environmental conditions. Spalling and runoff losses are observed on all metals. Massive reorganization of the corrosion film by a mechanism of cyclic dissolution and precipitation was observed on carbon steel, Cor-Ten A, zinc, and galvanized steel. Loss of corrosion product from zinc in runoff was a function of both dissolution in rain water and neutralization by hydrogen ion loading, with dissolution contributing to the greater portion of the loss.

OP 130–86. Reducing Methane Levels in Longwall Gobs, by F. Garcia and J. Cervik. Paper in Proceedings of Longwall USA Conference, Pittsburgh, PA, June 17–19, 1986, pp. 345–356. A test conducted in the Lower Kittanning Coalbed that indicates that up to 71 pct of the methane produced by a mining operation can be captured by a properly designed cross-measure system is described. The number, depth, spacing, and angle of boreholes is detailed, and methane flow at varying points during mining is discussed.

OP 131–86. A Subsidence Prediction Model for Longwall Mine Design, by Paul W. Jeran, Vladimir Adamek, and Michael A. Trevits. Paper in Proceedings of Longwall USA Conference, Pittsburgh, PA, June 17–19, 1986, pp. 102–112. It has been found that lithological conditions over the Pittsburgh Coalbed cause the subsidence coefficient to vary within the area of the subsidence trough. This precludes the use of European-developed predictive models, which are based upon a constant subsidence coefficient. Regression analysis of the distribution of subsidence coefficients from 11 Bureau of Mines, U.S. Department of the Interior, longwall panel studies on the location relative to the edge of the panel has yielded a third degree polynomial equation. This equation has been incorporated into a BASIC computer program for use on a personal computer that allows users with no previous knowledge of the

theory of subsidence to predict vertical movements over typical longwall panels in the Northern Appalachian Coal Basin.

OP 132–86. Expert Reasoning Models Applied to Mine Geologic Data, by Roger L. King. Paper in Proceedings of the 3rd Conference on the Use of Computers in the Coal Industry, Morgantown, WV, July 28–30, 1986, pp. 65–70. The Bureau of Mines has been involved with gathering and interpreting geologic data for 75 years. This experience has led to a high level of expertise within the Bureau and a desire to make it more accessible to the mining industry. With the recent advances in the field of artificial intelligence over the past few years, it has become more feasible to consider transferring knowledge to computers. Knowledge-based expert systems, the most active branch of artificial intelligence today, are computer programs that seek to combine a knowledge base of domain facts with expert-level decision making to arrive at plausible solutions to a problem. The intent of this paper is to examine some of the expert-level decision making models or "inexact reasoning" processes to determine their applicability to mine geologic data. This paper will describe two models that are available for this task and will give examples of applying these models to mine geologic data.

OP 133–86. A New Method of Rock Stress Management With Hydraulic Borehole Pressure Cells, by P. H. Lu. Paper in Proceedings of the International Symposium on Rock Stress and Rock Stress Measurements, Stockholm, Sweden, Sept. 1–3, 1986, pp. 237–245. This paper presents basic principles and required instrumentation for rock stress measurements with Bureau of Mines hydraulic borehole pressure cells. Existing stresses and stress changes can be measured with the same instrumentation. Based on the elastic theories of plates and thick-walled cylinders, the magnitude of biaxial rock stresses existing in a rock mass can be determined by pressure convergence-divergence tests using a combination of one cylindrical and two encapsulated flat hydraulic borehole pressure cells installed in a single drill hole. Case studies are included to demonstrate the validity of the technique.

OP 134–86. Assessment of the Low Frequency Whole Body Vibration Exposure Levels of Coal Mining Machinery Operators, by Gerald W. Redmond and Paul J. Remington. Paper in Progress in Noise Control, Volume II, ed. by Robert Lotz (Proc. 1986 International Conference on Noise Control Engineering, Cambridge, MA, July 21–23, 1986). Noise Control Found., Poughkeepsie, NY, 1986, pp. 917–920. This paper explores the effects of low frequency vibrations (below 1 Hz) from heavy machinery in coal mines. Recordings of low-frequency vertical vibrations collected during earlier studies were used to determine whether exposure to these vibrations caused "motion sickness" in mining machine operators, and the probability of overexposure to these vibrations using a variety of equipment such as bulldozers, front-end loaders, and scrapers is presented.

OP 135–86. A Catastrophe Model of Behavioral Accidents, by W. E. Souder. Paper in Proceedings of 1985 IEEE International Conference on Systems, Man, & Cybernetics, Tucson, AZ, Nov. 12–15, 1986. Inst. Electr. and Electron. Eng., 1985, pp. 514–515. This paper describes the relationship between individual psychological, group behavioral, and environmental variables, as well as other accident causing factors, and answers several long-standing questions about why some normally safe behaving persons occasionally engage in unsafe acts having high risks of serious injury. Ways to reduce the number of accidents are also discussed.

OP 136–86. Concentric Drill Steels for Noise Reduction of Percussion Drilling, by Robert R. Stein and William W. Aljoe. Paper in Progress in Noise Control, Volume I, ed. by Robert Lotz (Proc. 1986 International Conference on Noise Control Engineering, Cambridge, MA, July 21–23, 1986). Noise Control Found., Poughkeepsie, NY, 1986, pp. 333–336. This paper describes the design and test results of a prototype concentric drill steel used to reduce noise in large drills. Operational advantages of concentric vs. conventional steel, and the problems in coupling performance, are also discussed.

V. Patents

These patents, which may be used by any U.S. citizen or organization without royalty payment upon authorization by the U.S. Department of the Interior, were developed by Bureau scientists or under contracts with the Bureau. Application should be made to—

Branch of Patents
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U.S. Pat. 4,596,151. Biaxial Pressure Sensor. Richard A. Allwes. June 24, 1986.

U.S. Pat. 4,598,588. Detached Rock Evaluation Device. David R. Hanson. July 8, 1986.

U.S. Pat. 4,601,207. Measuring Mine Roof Bolt Strains. Bernard J. Steblay. July 22, 1986.

U.S. Pat. 4,601,795. Alloy Coating Method. Gerald R. Smith and John E. Allison, Jr. July 22, 1986.

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REPORTS OF INVESTIGATIONS

RI 9030. Correlating Abrasive Wear to Alloy Additions in Low-Alloy Steels, by J. H. Tylczak. 1986. 14 pp. 8 figs. The Bureau of Mines studied the effect of alloy additions on abrasive wear of low-alloy steels. A dry-sand, rubber-wheel abrasion test apparatus using ASTM G65–81 procedure B was used for the abrasive wear tests. Eighty-six material heat-treatment combinations were abrasion tested. Results of these tests were analyzed statistically using regression analysis to see if additions of Cr, Mn, Mo, Ni, Si, Al, Cu, and S were significant in affecting the abrasive wear rate of low-alloy steels. Regression analysis was also used to confirm hardness and C affect on the abrasive wear rate of these steels. It was found that for all the steels taken as a group, increased amounts of Mn significantly reduced the wear rate, while increased amounts of Mo and Si increased the wear rate. Analysis also confirmed previous research done by others, that increasing hardness and amounts of C reduced the wear rate. For the hardened steels taken as a class, only increasing amounts of C and Mn reduced the wear rate, while increases in Si increased the wear rate. In the class of unhardened steels, increases in C, Mn, and S reduced the wear rate, whereas increases in Mo increased the wear rate. The steels with the best resistance to wear were two hardened experimental steels similar to AISI 1055 and AISI 1078.

RI 9031. Gas Equilibrium in Sealed Coal Mines, by Charles D. Litton. 1986. 13 pp. 8 figs. This Bureau of Mines report presents new concepts and procedures that have been derived for determining ambient equilibrium conditions in sealed coal mines. In particular, these concepts address problems usually encountered in determining the return of a mine to ambient temperature levels after it has been sealed due to a fire. These concepts are applied to six sealed mine fire incidents with good agreement.

RI 9032. Removal of Alkalies From Portland Cement Kiln Dust, by R. D. Wilson and W. E. Anable. 1986. 10 pp. 8 figs. Ten to twelve million tons of dust is produced by cement kilns annually in the United States, resulting in a serious waste disposal problem. The Bureau of Mines investigated two alkali volatilization methods for converting this dust into materials for making portland cement and a useful potassium product. Portland cement kiln dust was found to be composed of finely ground cement raw materials ($CaCO_3$ and SiO_2) having a layer of alkali sulfate (K_2SO_4 and Na_2SO_4). In this form, it cannot be directly recycled to cement kilns because concrete is weakened by a reaction between the alkali and the aggregate. Portland cements with 28-day strengths above 5,000 psi were produced from low-alkali residues using sintering and melting methods. For nearly complete removal of alkalies, primarily potassium sulfate, from cement kiln dust, a temperature above 1,300° C and a reducing atmosphere were required.

RI 9033. Measurement of Coal-Cutting Forces Underground With the In-Seam Tester, by Laxman S. Sundae. 1986. 16 pp. 9 figs. The Bureau of Mines designed, fabricated, and is using an in-seam tester for in situ determination of coal cutting forces. This report describes the results of field tests conducted in the Pocahontas No. 3 and Upper Freeport seams to obtain peak and mean cutting forces during coal cutting with several bit geometries, including radial and point attack bits currently used on drum-type machines. Comparisons were also made between new and worn bits, and by using data obtained from a Bureau-modified chisel bit. The test results show that longwall plough cutting (horizontal cuts) in bony coal bands (shale) requires greater than three times the cutting force for the same cuts in a vertical direction. When no bony coal is present, the cutting forces required to make horizontal and vertical cuts are equal. Worn bits require four to five times more cutting and normal force than new or undamaged bits. Normal force increased drastically for the worn chisel bit. Peak force encountered in making independent cuts was found to be approximately three times higher than that required to make interactive cuts using a spacing-to-depth-of-cut ratio of 2. Both rake and clearance angles were found to have a significant effect on normal and cutting force.

RI 9034. Experimental Nickel-Cobalt Recovery From Melt-Refined Superalloy Scrap Anodes, by J. L. Holman and L. A. Neumeier. 1986. 17 pp. 6 figs. The Bureau of Mines is conducting research to recover strategic and critical metals such as Ni, Co, and Cr from mixed contaminated superalloy scrap. One approach being studied involves melt refining of superalloy scrap to produce anodes for electrolytic deposition of Ni-Co alloy. This melt refining of superalloy turnings is described based on melt-oxidation and oxidation-carburization experiments that use roasted superalloy grinding sludge to supply the O needed to oxidize Cr and other readily oxidized elements to the slag. Controlled melt-carburization subsequent to oxidation improved the metal phase recovery of Ni and Co to sell over 90 pct and decreased electrolytic solubility of Cr, Mo, and W by carbide formation. Electrolytic refining experiments were conducted using a controlled-potential mode (preset cathode potential). Data show effects of Fe and Cr impurities, cation concentration, electrolyte pH, SO_4-Cl electrolyte ratio, temperature, cathode potential, and cation-selective membrane use on current efficiency, current density, and deposit composition. Disposition of Ni, Co, Cr, Mo, W, and Fe is compared for melt-oxidized versus oxidized-plus-carburized anodes. Deposits containing >97 pct Ni + Co (major impurity Fe) have been routinely obtained from scrap anodes. Research is continuing to improve deposit quality in sustained deposition and to recover Cr and other metals from refining slags and anode sludges.

RI 9036. An Infrared Examination of Ion-Exchanged Montmorillonite Treated With Polyethylene Oxide, by Steve W. Webb, D. A. Stanley, and B. J. Scheiner. 1986. 16 pp. 13 figs. The Bureau of Mines is researching a new technology for dewatering clay suspensions that consists of flocculation by high-molecular-weight polyethylene oxide (PEO) polymer and subsequent removal of water from the flocs via a trommel. The minimum amount of PEO required to dewater the clays depends on the ions adsorbed on the surface of the clay particles. Infrared studies were performed on clays with Li^+, NH_4^+, K^+,

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Mg^{2+}, Ca^{2+}, Ba^{2+}, or Sr^{2+} adsorbed, with and without adsorbed PEO, to develop data to aid in understanding the dewatering mechanism. Hydroxyl stretching modes between 3,400 and 3,250 cm^{-1}, associated with water adsorbed on the clay, showed changes in intensity proportional to the ionic charge-to-radius ratio; that is, the ionic potential. In addition, a water-bending vibration of adsorbed water at 1,630 cm^{-1} showed variations associated with water desorption. The data are consistent with changes in adsorption of PEO resulting from variation of the acidity of water coordinated with the exchange ions, induced by the variation in field strength of the ions with the ionic potential. This report is based upon work done under an agreement between the University of Alabama and the Bureau of Mines.

RI 9037. Using Barriers To Reduce Dust Exposure of Longwall Face Workers, by Robert A. Jankowski and Charles A. Babbitt. 1986. 10 pp. 9 figs. Through laboratory and underground studies, the Bureau of Mines has evaluated the use of passive barriers (dust shields) to help confine dust generated by longwall shearers to the face area. Laboratory studies focused first on selection of the optimum barrier design—a simple, gobside barrier (made of conveyor belting) coupled with a headgate splitter arm—to prevent the dust cloud from entering the walkway at the headgate end of the shearer when cutting tail to head. Further laboratory testing was done to determine whether using passive barriers in combination with different water-spray dust-reduction methods, including the shearer-clearer system developed by the Bureau, would improve dust reduction over that from using the water sprays alone. It was found that the combination of gobside passive barriers plus the full shearer-clearer system was most effective, and surmised that this would be especially useful in thicker seams. However, underground testing revealed that the shearer-clearer system alone was 35 pct more effective in reducing dust contamination than when used with the gobside passive barriers, and far more effective than using passive barriers with a conventional water spray system. For such an effective system as the shearer-clearer, the reduction in available space over the top of the machine actually impeded system performance; this was shown in both eastern and western mines. But when used with comparatively inefficient water spray systems, the passive barriers, used in combination with a headgate splitter arm, provide considerable help in reducing dust levels in the walkway.

RI 9038. Testing Materials for Support-Wall Construction, by Kenneth E. Hay and Joanne L. Johnston. 1986. 11 pp. 8 figs. The Bureau of Mines collected coal and coal waste aggregate material from two different mine sites to determine their strength characteristics for use in concrete. The concrete would be placed underground as support walls for ground control in adverse conditions or unique mining applications. A standard mix design was established for a "wet" mix using a water-to-cement (w/c) ratio of 1.0 to facilitate pumping into place. Later, material was collected from four more mine sites and used to make 2- by 2- by 2-ft test blocks with the same w/c ratio. A pullout cone device and borehole shear tester were used to determine the in situ material strength of the test blocks. These techniques will provide a simple and quick way of determining support wall strength in an underground environment. Test results from the pullout cone device showed a good correlation of 0.98 to test cylinder compressive strengths of the same mix. Results of the borehole shear tester were inconclusive.

RI 9039. High-Temperature Relative Enthalpies of V_2O_5, by M. J. Ferrante and R. V. Mrazek. 1986. 7 pp. Relative enthalpies of V_2O_5 from 298.15 to 1,101.0 K were measured at the Bureau of Mines to provide data needed for the advancement of mineral technology. Enthalpies were measured with a copper-block calorimeter. A sharp melting point was found at 951 K, with Δ°_m = 15.690 kcal/mol for the standard enthalpy of melting. Tabulated values are given at selected temperature increments between 298.15 and 1,500 K for the standard relative enthalpy ($H^\circ - H^\circ_{298}$), heat capacity (C_p°), entropy (S°), and Gibbs energy function $[-(G^\circ - H^\circ_{298})/T]$. Standard relative enthalpies are also given in equation form and combined with data from the literature to derive values of standard enthalpies of formation and Gibbs energies of formation.

RI 9041. Deposition of Respirable Coal Dust in an Airway, by Welby G. Courtney, Lung Cheng, and Edward F. Divers. 1986. 10 pp. 7 figs. Because of the inherent safety problem associated with the deposition of airborne respirable dust onto the floor and other airway surfaces, the Bureau of Mines investigated the rate of reduction of airborne respirable dust in an airway due to deposition of the particles onto the surfaces of the airway. The effects of relative humidity and air velocity on the deposition rate were examined. It was found that the deposition rate was comparable in magnitude with the Stokes sedimentation rate and that it was independent of relative humidity. However, near the dust source the deposition rate depended significantly upon the air velocity, with such dependence decreasing with increasing distance from the dust source. In addition, the size distribution of the airborne particles was approximately constant along the first 300 ft of the airway, indicating that it was not merely the larger (heavier) particles that were being deposited. These results suggest that deposition, though comparable with the Stokes sedimentation rate in magnitude, does not follow a simple Stokes-type process, and that the process of deposition remains to be explained.

INFORMATION CIRCULARS

IC 9073. Underground Coal Mine Lighting Handbook. (In Two Parts.) 1. Background, compiled by W. H. Lewis. 1986. 42 pp. 60 figs. This Bureau of Mines report and its companion report (Information Circular 9074) have been prepared as a complete reference on underground coal mine lighting. This report discusses the fundamentals of light and its interrelationship with the visual process. The purpose of the report is to insure an understanding of the numerous complex and interrelated factors that must be considered to design and implement a mine lighting system that will satisfy human needs for good vision and comfort. Topics include history, objectives, and technical considerations of coal mine lighting; light physics; light and vision relationships; and disability and discomfort glare.

IC 9074. Underground Coal Mine Lighting Handbook. (In Two Parts.) 2. Application, compiled by W. H. Lewis. 1986. 89 pp. 79 figs. This Bureau of Mines report and its companion report (Information Circular 9073) have been prepared as a complete reference on underground coal mine lighting. This report discusses system design criteria and procedures, data and specifications to aid in selection of suitable mine lighting hardware, and guidelines for system installation and maintenance. Topics include light measuring techniques and instruments, illumination regulations for underground coal mine environments and equipment, lamps and ballasts, available mine lighting hardware, design and evaluation of coal mine illumination systems, and installation and maintenance of a mine lighting system.

IC 9080. Economic Evaluation of Horizontal Borehole Drilling for Methane Drainage From Coalbeds, by Eugene C. Baker, Roy H. Grau III, and Gerald L. Finfinger. 1986. 18 pp. 3 figs. The potential profitability of a horizontal borehole drilling program for recovering methane gas in an Alabama coalbed for 6 yr in advance of mining is estimated in this Bureau of Mines report. A cash flow analysis based on estimated capital investments, annual operating costs, and the selling price of methane gas was used to determine the net income and net cash flow for each year of operation. Subsequently, the annual net cash flows were capitalized to determine the discounted cash flow rate of return. Findings indicate that a 25.08-pct interest rate of return on investment could be realized from the sale of methane gas in excess of 3 billion ft^3 during the years 1985 through 1990 at a minesite price of $2.25/Mft^3$.

IC 9083. Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS, by Robert C. Dyni. 1986. 23 pp. 21 figs. The Bureau of Mines in cooperation with the Solution Mining Research Institute conducted surface and subsurface

investigations over five solution-mined salt cavities in the Hutchinson, KS, area. The purpose of these investigations was to determine the mechanisms that lead to the formation of sinkholes above collapsed solution cavities. Of the five salt-solution cavities investigated, four had collapsed and produced sinkholes prior to the time of the investigations; the fifth cavity was considered stable. Exploratory drilling and coring operations were conducted at all five sites; surface stability monitoring was conducted at three of them. The results of these studies indicate that excessive dissolution at the salt-shale contact of each collapsed cavity produced large, unsupported roof spans that ultimately exceeded the structural integrity of the overburden. The stable cavity was not exposed to excessive dissolution at the salt-shale contact; this limited the roof span and ensured a stable cavity. The data also show that surface settlement in the vicinity of the two surface-monitored sinkholes continued for approximately 7 years after the sinkholes formed, indicating that the rubble piles of the collapsed cavities were undergoing gradual consolidation. This report is based upon work done under an agreement between the Solution Mining Research Institute and the Bureau of Mines.

IC 9088. Reliability Prediction for Computerized Mine-Monitoring Systems, by Raymond M. Kacmar and Edward F. Fries. 1986. 13 pp. 17 figs. This report presents the Bureau of Mines research on the hardware reliability prediction for two Bureau monitoring projects. The basic concepts of reliability predictions are introduced along with the reliability models and assumptions used for this particular evaluation. The results of the reliability predictions are for ground-fixed and naval-sheltered environments.

IC 9089. Impact of Background Sources on Dust Exposure of Bag Machine Operator, by Andrew B. Cecala and Edward D. Thimons. 1986. 10 pp. 10 figs. The Bureau of Mines has recorded a number of different background dust sources that significantly contaminate the air breathed by bag machine operators. These background sources, observed at five different plants over the past 2 years, can expose bag machine operators to more significant dust concentrations than the filling process itself. To keep bag operator exposure within acceptable dust levels established by the Mine Safety and Health Administration, U.S. Department of Labor, the significance of these background sources must be realized, and the sources must be identified and controlled. The purpose of this work is to identify common background dust sources and show the significant effects that they have on the bag operator's overall dust exposure.

IC 9091. Placer Gold Sampling In and Near the Chugach National Forest, Alaska, by Robert B. Hoekzema and Steven A. Fechner. 1986. 42 pp. 19 figs. The Bureau of Mines and U.S. Geological Survey completed a 4-yr (1979–82) mineral appraisal of the Chugach National Forest (CNF), AK. This report summarizes the Bureau's placer gold studies in the CNF. Placer mining from the mid-1890's through 1982 produced an estimated 133,800 oz of gold, of which two-thirds was produced prior to 1920. As much as 6,800 oz of placer gold was produced from 1979 to 1982. Most production came from Crow, Canyon, and Resurrection Creeks. Five types of placer gold deposits were identified in the CNF: (1) alluvial placers, (2) bench placers, (3) eluvial placers, (4) glacial placers, and (5) marine placers. Placer sampling indicated a potential for gold production from alluvial and bench placers associated with historically mined drainages such as Crow, Canyon, Resurrection, Sixmile, and Mills Creeks and from unmined drainages including the Avery, Kings, Snow, Copper, and Tasnuna Rivers and several smaller streams throughout the CNF. Results of fineness tests indicated that gold from the CNF ranges from 455 to over 950 fine. Subsequent investigations in drainages with anomalous placer sample values also identified previously unknown lode mineralization.

SPECIAL PUBLICATION

SP 1–86. Mineral Position of the United States: The Past Fifteen Years. The 1985 Annual Report of the Secretary of the Interior Under the Mining and Minerals Policy Act of 1970, by Staff, Bureau of Mines. 1986. 45 pp. 12 figs. In addition to describing the performance of the nonfuel mineral industry during 1985, this report reviews the changes that have taken place in the Nation's mineral position since the passage of the Mining and Minerals Policy Act of 1970. Changes in mineral demand and foreign competition for world markets are analyzed, and responses of Government and industry to these changes are discussed.

BULLETIN

B 682. Recovery of Tungsten From Searles Lake Brines by an Ion-Exchange Process, by P. B. Altringer and others. 1985. 47 pp. 23 figs. Searles Lake, CA, contains the largest known domestic tungsten resource. The brines in this near-dry lake bed, located in the Mojave Desert 130 mi northeast of Los Angeles, contain an estimated 135 MMlb of tungsten. However, the low concentration of tungsten (0.080 g/L WO_3) in the supersaturated brine makes selective tungsten extraction very difficult. Although many brine chemicals are extracted from the lake, tungsten recovery was an elusive goal prior to Bureau of Mines development of an ion-exchange technique. This publication describes the Bureau process, the Searles Lake resource, general problems associated with tungsten recovery, Bureau research objectives, the synthesis of ion-exchange resins, the development of a two-stage ion-exchange tungsten extraction and concentration procedure, product recovery and purification, and provides an economic evaluation. Flowsheets for recovering three products (calcium tungstate, sodium tungstate, and tungstic oxide) are presented and evaluated, as well as a summary of the research effort and potential applications.

PREPRINTS FROM MINERALS YEARBOOK, 1985

These preprints are chapters from Minerals Yearbook, 1985. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

Abrasive Materials, by Staff, Bureau of Mines. 14 pp.
Antimony, by Patricia A. Plunkert. 9 pp.
Barite, by Sarkis G. Ampian. 11 pp.
Boron, by Phyllis A. Lyday. 8 pp.
Chromium, by John F. Papp. 17 pp.
Cobalt, by William S. Kirk. 10 pp.
Columbium and Tantalum, by Larry D. Cunningham. 12 pp.
Gem Stones, by Staff, Bureau of Mines. 10 pp.
Gold, by J. M. Lucas. 36 pp.
Graphite, by Harold A. Taylor, Jr. 11 pp.
Helium, by William D. Leachman. 8 pp. 3 figs.
Lime, by Lawrence Pelham. 10 pp. 1 fig.
Manganese, by Thomas S. Jones. 14 pp.
The Mineral Industry of Burma, by Gordon L. Kinney. 5 pp.
The Mineral Industry of Israel, by Ben A. Kornhauser. 4 pp.
The Miners' Industry of Namibia, by George A. Morgan and Francis E. Shafer. 5 pp.
The Mineral Industry of Yugoslavia, by Roman V. Sondermayer. 16 pp.
Other Metals, by Staff, Divisions of Nonferrous and Ferrous Metals. 24 pp.
Platinum-Group Metals, by J. Roger Loebenstein. 12 pp.
Rare-Earth Minerals and Metals, by James B. Hedrick. 13 pp.
Silicon, by Gerald F. Murphy. 13 pp.
Sulfur, by David E. Morse. 22 pp. 4 figs.
Talc and Pyrophyllite, by Robert L. Virta. 7 pp.
Tungsten, by Philip T. Stafford. 15 pp.
Zirconium and Hafnium, by W. Timothy Adams. 9 pp.

II. Open File Reports—NTIS

An open file report is an unpublished Bureau of Mines report that has been made available as reference material. Any open file report may be inspected during working hours at the locations

indicated but may not be removed, except that the Natural Resources Library, U.S. Department of the Interior, Washington, DC 20240, can usually supply copies on interlibrary loan. For further information, contact the library, 202–343–5815.

If a number prefixed with PB is given, the report may be purchased by check or money order payable to the National Technical Information Service, charged to a deposit account at NTIS, or charged on a VISA, MasterCard, or American Express credit card. Address requests to—

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In the open file listings that follow, the symbols indicate facilities where reports are available for inspection. (See list for key symbols.)

AD/MDA	Assistant Director—Mineral Data Analysis, USBM, Washington, DC.
AD/MI	Assistant Director—Minerals Information, USBM, Washington, DC.
AD/MMR	Assistant Director—Minerals and Materials Research, USBM, Washington, DC.
AD/MR	Assistant Director—Mining Research, USBM, Washington, DC.
AFOC/A	Alaska Field Operations Center, USBM, Anchorage, AK.
AFOC/F	Alaska Field Operations Center, USBM, Fairbanks, AK.
AFOC/J	Alaska Field Operations Center, USBM, Juneau, AK.
ALRC	Albany Research Center, USBM, Albany, OR.
AVRC	Avondale Research Center, USBM, Avondale, MD.
DOI	U.S. Department of the Interior.
DRC	Denver Research Center, USBM, Denver, CO.
IFOC	Intermountain Field Operations Center, USBM, Denver, CO.
LIB	Natural Resources Library, DOI, Washington, DC.
MSHA	Mine Safety and Health Administration, Arlington, VA.
NMH&SA	National Mine Health and Safety Academy, Beckley, WV.
OSM	Office of Surface Mining Library, DOI, Washington, DC.
PRC/B	Pittsburgh Research Center (Bruceton), USBM, Pittsburgh, PA.
RERC	Reno Research Center, USBM, Reno, NV.
RORC	Rolla Research Center, USBM, Rolla, MO.
SLRC	Salt Lake City Research Center, USBM, Salt Lake City, UT.
SRC	Spokane Research Center, USBM, Spokane, WA.
TCRC	Twin Cities Research Center, USBM, Twin Cities, MN.
TURC	Tuscaloosa Research Center, USBM, Tuscaloosa, AL.
USBM	U.S. Bureau of Mines.
WFOC	Western Field Operations Center, USBM, Spokane, WA.

OFR 48–86. Noise Study of Longwall Mining Systems, by Mark R. Pettitt and Robert M. Slone, Jr. Jan. 1986. 169 pp. 91 figs. An investigation was conducted to identify and promote the application of noise control technology to future longwall mining machinery. Intensive noise and vibration data were acquired on a typical longwall shearing machine, and the highest noise levels were shown to radiate from the cutter drums. Shearing machine cutter drum noise control techniques that take advantage of the nature of the dynamic forces generated during coal cutting were developed. These include both structural redesign and force isolation techniques. A reduced noise cutter drum was developed that achieved a 5- to 6-dBA system noise reduction at the operator's position. Its operational performance was verified by a 6-month-long in-mine test. It was evident from the data that additional noise reduction could be achieved by treatment of the shearing machine hydraulics. Noise control of secondary sources was also investigated. A method of reducing full or empty stage conveyor noise (and continuous miner conveyor noise) by 5 to 10 dBA was demonstrated through isolation techniques. Underground mine durability testing, however, is yet to be demonstrated. Research was done under contract J0188072 by Wyle Laboratories. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 87–102257; paper copy price code A08. $16.95.

OFR 52–86. Financing Foreign Development of Non-Fuel Mineral Resources: An Analysis of Loan Terms of International Financial Institutions vs. Those of Commercial Banks, by Price Waterhouse. May 16, 1986. 310 pp. 58 figs. This report presents the results of a study comparing loan terms for nonfuel mineral projects in developing countries from various international financial institutions (IFI's) and from private sector commercial sources. The study compares IFI and commercial loan terms for seven mineral projects in developing countries. The IFI's represented are the International Bank for Reconstruction and Development (World Bank), the International Finance Corporation, the Inter-American Development Bank, the Asian Development Bank, and the International Monetary Fund. In addition, the costs of financing for these mineral projects were compared with the costs of long-term debt to five large U.S. mineral producers. Research was done under contract J0156023 by Price Waterhouse. Available for reference at AD/MDA, AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 86–247228; paper copy price code A14. $28.95.

OFR 77–86. Silver Extraction From Marginal Resources, by H. J. Heinen, D. G. Peterson, and R. E. Lindstrom. 1975. 17 pp. 9 figs. Modification of conventional cyanidation processes are being investigated by the Bureau of Mines to develop more efficient methods of extracting silver values from mine wastes and low-grade and refractory ores. One technique developed involves the selective precipitation of silver as Ag_2S from cyanide solutions followed by recovery of residual gold values on activated carbon. Carbon-in-pulp cyanidation appears promising for processing slimy tailings with the development of an efficient technique for stripping silver from loaded carbon with alkaline ethanol solutions at ambient temperature and pressure. Salt roasting-cyanidation treatment of a refractory ore gave 88% silver extraction compared with 60% attained by conventional cyanidation. The chloridized calcine is amenable to percolation or heap leaching with dilute cyanide solution. Research was done by the U.S. Bureau of Mines Reno Research Center. Available for reference at AD/MMR, ALRC, AVRC, LIB, RERC, RORC, SLRC, and TURC. Order ONLY from NTIS: PB 86–245917; paper copy price code A02. $9.95.

OFR 79–86. Capital and Operating Cost Estimating System Handbook for Alumina Refinery Facilities, by R. F. Neider. May 1985. 177 pp. 3 figs. This report provides the methodology for developing capital and operating costs related to an alumina refinery. The costs developed are for a mid-United States location with the methodology prepared to allow translation of costs worldwide. Also, costs for environmental and alternative unit processes are identified. Research was done under contract J0245003 by Raymond Kaiser Engineers Inc. Available for reference at AFOC/J, IFOC, LIB,

and WFOC. Order ONLY from NTIS: PB 86-246568; paper copy price code A08. $16.95.

OFR 80-86. Capital and Operating Cost Estimating System Handbook for Aluminum Smelter Facilities, by R. F. Neider. Aug. 1985. 196 pp. 6 figs. This report provides the methodology for developing capital and operating costs for aluminum smelter facilities. The costs developed are for a mid-United States location with the methodology prepared to allow translation of costs worldwide. Also, costs for environmental and alternative unit processes are identified. Research was done under contract J0245003 by Raymond Kaiser Engineers Inc. Available for reference at AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 86-246576; paper copy price code A09. $16.95.

OFR 81-86. Capital and Operating Cost Estimating System Handbook for Lead Smelting and Refining Facilities, by R. F. Neider. Apr. 1985. 282 pp. 6 figs. This report provides the methodology for developing capital and operating costs related to lead smelting and refinery facilities. The costs developed are for a mid-United States location with the methodology prepared to allow translation of costs worldwide. Also, costs for environmental, secondary smelting, and alternative technology processes are identified. Research was done under contract J0245003 by Raymond Kaiser Engineers Inc. Available for reference at AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 86-246592; paper copy price code A12. $22.95.

OFR 82-86. Capital and Operating Cost Estimating System Handbook for Electrolytic Zinc Refining Facilities, by R. F. Neider. Sept. 1985. 199 pp. 6 figs. This report provides the methodology for developing capital and operating costs for electrolytic zinc refining facilities. The costs developed are for a mid-United States location with the methodology prepared to allow translation of costs worldwide. Also, costs for environmental and alternative unit processes are identified. Research was done under contract J0245003 by Raymond Kaiser Engineers Inc. Available for reference at AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 86-246584; paper copy price code A09. $16.95.

OFR 85-86. Preliminary Mine, Prospect, and Sample Location Maps and Descriptions, Juneau Gold Belt Area, by Earl Redman, William S. Roberts, Al Clough, and Joseph Kurtak. May 29, 1986. 68 pp. 5 figs. This report describes Bureau of Mines fieldwork that revealed the locations of numerous adits, shafts, and other old mine workings, many of which were previously unreported or misplotted on existing published maps of the Juneau Gold Belt portion of the Juneau Mining District, an area which has produced $157,000,000 worth of gold, silver, and lead since 1880. The Bureau examined approximately 85 mines, prospects, and occurrences during this study, interviewed local prospectors, claim owners, and geologists, and conducted an extensive literature search that included reports by the U.S. Geological Survey, the State of Alaska, and the Bureau of Mines, as well as unpublished private company reports. Research was done by the U.S. Bureau of Mines Alaska Field Operations Center at Anchorage, AK. Available for reference at AD/MDA, AFOC/J, IFOC, and WFOC. Copies of this report will not be available for purchase.

OFR 86-86. Development of the Capacity To Assess Occupational Noise Overexposure in the Mining Industry, by A. G. Galaitsis. Feb. 1986. 205 pp. 9 figs. The purpose of this work was to expand and improve the scope and accuracy of the method developed for the prediction of the number of workers overexposed to noise in the mining industry. A significant portion of the noise data were acquired during mine visits that took place in the course of this study. These data were obtained with time-resolved dosimeters, which among other things store a time history of the sampled noise for an 8-hour work period. The remainder of the noise data have been obtained from MSHA files and from other Bureau of Mines projects. The report reviews the prediction model, discusses the model's assumptions and approximations, describes the function of the developed software, offers typical examples on the use of the software, and includes plots of the newly acquired data records. Research was done under contract J0245001 by BBN Laboratories Inc. Available for reference at ALRC, AVRC, DRC, LIB, MSHA, NMH&SA, OSM, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 87-106191; paper copy price code A10. $22.95.

OFR 88-86. Design, Construction and Mine Testing of a Device for Installing Cement-Grouted Roof Bolts, by Douglas W. Ounanian and Robert L. Cardenas. Apr. 1986. 130 pp. 31 figs. Inorganic cement grouts for roof bolting applications provide an alternative to resin-grouted bolts. Inorganic cement grout is nonflammable, nontoxic, and nonallergenic and offers the potential for significant savings over petroleum-based resin if it can be mixed and injected cheaply and reliably. This report describes the development and testing of a device that mixes on demand and injects cement-based grouts for roof bolting. The grout mix-inject system mixes dry cement with water to form grout, pumps it into a delivery hose, and injects it into the roof bolt hole. The mixing and pumping system is based on a twin screw extruder. The geometry of the twin screws is such that the unit is self-cleaning. The injection is performed pneumatically, and no hardware is placed up the hole. The bolter-mounted device was developed through laboratory testing during which injections were made into simulated bolt holes drilled in concrete. The underground testing and evaluation program demonstrated the ability of the system to install competent cement-grouted roof bolts. Research was done under contract H0202027 by Foster-Miller, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, MSHA, NMH&SA, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 87-106233; paper copy price code A07. $16.95.

OFR 89-86. Distribution, Analysis, and Recovery of Placer Gold From the Porcupine Mining Area, Southeast Alaska, by Robert B. Hoekzema, Steven A. Fechner, and Tom Bundtzen. 1986. 49 pp. 14 figs. The Bureau of Mines (Bureau) and the Alaska Division of Geological and Geophysical Surveys (ADGGS) completed an evaluation of the placer resources of the Porcupine Mining Area near Haines, AK, during 1985. The Bureau sampled and evaluated the placer deposits, and the ADGGS mapped and geology and summarized the glacial geologic history of the area. This report summarizes the results of the study. Gold was discovered along the Klehini River in 1898. A gold rush ensued that resulted in the discovery of gold on Porcupine Creek and nearby drainages and that has produced 79,650 oz of raw placer gold, most prior to 1936. Three types of placer deposits occur in the area: (1) stream channel gravels, (2) bench placers, and (3) alluvial fans. Organic material from bench deposits were age dated from 2,100 to 2,700 years ago. Each of these deposit types was sampled to estimate resources, identify gold fineness, determine mineral development potential ratings for streams, and calculate optimum screening sizes for use in recovery plants. Identified resources include 932,000 yd^3 of gravel rated as having moderate or high mineral development potential. Bulk character studies of gravel from Lower Porcupine Creek indicate that washing plants should be designed to screen to minus 1 mesh and recover gold to plus 80 mesh. Gold fineness of 13 samples ranged from 669 to 902 and averaged 837. Research was done by the Bureau of Mines and the State of Alaska Division of Geological and Geophysical Surveys. Available for reference at AFOC/J, IFOC, and WFOC. Copies of this report will not be available for purchase.

OFR 91-86. History of the Juneau Gold Belt, 1869-1985: Development of the Mines and Prospects From Windham Bay to Berners Bay, by Earl Redman. 1986. 78 pp. 32 figs. This report chronicles the exploration and mining development history of the Juneau Gold Belt from the discovery of the first placer gold in 1869 to the reevaluation of the economic potential of the Alaska Juneau Mine in 1985. Using an outline form, historical information is given year by year for most of the mines and prospects in the Gold Belt. The report includes information about initial discoveries, timing of mine exploration, construction of mills, mining problems and closures, and pertinent general history. Research was done by

the U.S. Bureau of Mines Alaska Field Operations Center at Juneau, AK. Available for reference at AD/MDA, AFOC/J, IFOC, LIB, PRC/B, and WFOC. Copies of this report will not be available for purchase.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 55–86. Mineral Resources of the Southern Inyo Study Area, Inyo County, California, by Charles Sabine, Eric E. Cather, Lucia Kuizon, and Michael C. Horn. 1986. 115 pp. 17 figs. Western Field Operations Center, Spokane, WA.

MLA 56–86. Mineral Resources of the South Pahroc Range Wilderness Study Area, Lincoln County, Nevada, by Terry R. Neumann. 1986. 21 pp. 5 figs. Western Field Operations Center, Spokane, WA.

MLA 58–86. Mineral Investigation of a Part of the Fifty Mile Mountain Wilderness Study Area (UT–040–080), Kane County, Utah, by Clay M. Martin. 1986. 37 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

MLA 59–86. Mineral Investigation of a Part of the Scorpion Wilderness Study Area (UT–040–082), Garfield County, Utah, and North Escalante Canyon (V) Instant Study Area, Kane County, Utah, by Patricia A. Corbetta. 1986. 9 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MLA 61–86. Mineral Resources of the Burnt Creek Study Area, Custer County, Idaho, by Peter N. Gabby. 1986. 12 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MINERAL INSTITUTES REPORTS

The mineral institutes program operates under Public Law 98–409 and under title III of Public Law 95–87. It is designed to improve the quality of mineral engineering research and education through support for research in mining, metallurgical processing, and related mineral sciences. The Bureau of Mines supports this research through annual allotment grants, matched by non-Federal funds, to mineral institutes at 31 universities throughout the United States, and by research grants to these institutions to address specific mining and processing problem areas.

The following reports describe research conducted under research grants. Individual copies may be available from the authors of the papers at the university cited. Copies of these reports are NOT available from the Bureau of Mines.

MIR 4–86. The Solubility and Stability of Scorodite, $FeAsO_4 \cdot 2H_2O$, by Patricia Martin Dove and J. Donald Rimstidt. Am. Mineral., v. 70, 1985, pp. 838–844. Scorodite is an orthorhombic iron arsenate commonly associated with arsenic-bearing ore deposits as a weathering product. This study investigated the mode of formation and persistence of scorodite in nature, and suggests that its presence controls the arsenate levels in waters draining from oxidizing arsenic-rich ores. Observations at the Brinton arsenic mine, Floyd County, VA, among other arsenopyrite deposits, show a close spatial relationship between arsenopyrite and scorodite. Analysis of the surface and ground waters at the Brinton arsenic mine site showed that scorodite seems to control maximum dissolved arsenate levels. This research was done under grant G1134151 at the Virginia Polytechnic Institute and State University.

MIR 5–86. Gahnite in the Metamorphosed Stratiform Massive Sulfide Deposits of the Mineral District, Virginia, U.S.A., by D. J. Sandhaus and J. R. Craig. Tschermaks Mineral. Petrogr. Mitt., v. 35, 1986, pp. 77–98. This paper describes the analysis of 580 polished sections and 50 thin sections from samples and diamond drill cores from the mineralized zones of the Cofer, Arminius, Sulphur, and Julia stratiform sulfide deposits of Louisa County, VA. The presence of gahnite in these rocks and its potential as a exploration guide in the search for massive deposits of sulfide ore are also discussed. This research was done under grant G5105053 at the Virginia Polytechnic Institute and State University.

MIR 6–86. Rates of Reaction of Covellite and Blaubleibender Covellite With Ferric Iron at pH 2.0, by Carol Ann Walsh and J. Donald Rimstidt. Can. Mineral., v. 24, 1986, pp. 35–44. This study evaluates the rates of oxidation of covellite and blaubleibender (blue-remaining) covellite by Fe^{3+} at pH 2 in a batch reactor system to better understand the geochemical processes involved in second-cycle weathering of enriched zones of copper-bearing ore deposits. This research was done under grant G1134151 at the Virginia Polytechnic Institute and State University.

III. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 137–86. Thermodynamic Properties of Calcium Zirconate ($CaZrO_3$), by R. R. Brown and K. O. Bennington. Thermochim. Acta, v. 106, 1986, pp. 183–190. Characterized synthetic $CaZrO_3$ was used by the Bureau of Mines to determine the standard enthalpy of formation (ΔH^0_{298} = -424.58 ± 0.47 kcal mol^{-1}; -1776.43 ± 1.97 kJ mol^{-1}) and the standard enthalpy of formation from the oxides (ΔH^0_{298} (from oxides) = -9.75 ± 0.11 kcal mol^{-1}; -40.78 ± 0.46 kJ mol^{-1}) at 298.15 K. This compound, easily prepared and characterized, is potentially useful for a calorimetric standard. The reaction scheme for hydrofluoric acid solution calorimetry does not require a reaction step adding liquid to the solvent.

OP 138–86. Column Flotation of Chromite and Fluorite Ores, by D. G. Foot, Jr., J. D. McKay, and J. L. Huiatt. Can. Metall. Q., v. 25, No. 1, Jan.-Mar. 1986, pp. 15–21. The Bureau of Mines investigated column versus conventional flotation of chromite and fluorite ores. Fine-bubble column flotation of deslimed chromite ore produced a 44.7% Cr_2O_3 rougher concentrate at 87.1% recovery, whereas conventional flotation produced a 40.4% Cr_2O_3 concentrate at 85.4% recovery. Column flotation of undeslimed chromite ore also produced results superior to those attained with conventional flotation. Column flotation of fluorite ore produced a 90.9% CaF_2 rougher concentrate at 86.8% recovery, compared with a 67% CaF_2 rougher concentrate at 90.4% recovery produced by conventional flotation.

OP 139–86. Computer Modeling To Evaluate the Effect of Cutting System Changes on Relative Dust Generation, by B. D. Hanson and W. W. Roepke. Paper in Proceedings of the Third Conference on the Use of Computers in the Coal Industry, Morgantown, WV, July 28–30, 1986, ed. by Y. J. Wang, R. Larry Grayson, and Richard L. Sanford. A. A. Balkema, 1986, pp. 235–239. Interactive computer programs are being developed by the Bureau of Mines that allow the user to analyze the effect of changes in cutting system parameters on relative dust generation. These programs are written in BASIC for use on microcomputers. Their interactive structure allows the user to evaluate the effect of parameter changes either collectively or individually. This paper describes the basic calculations used by the programs and their general use.

OP 140–86. A Subsidence Prediction Model for Longwall Mine Design, by Paul W. Jeran, Vladimir Adamek, and Michael A. Trevits. Ch. 1 in Mine Subsidence (Proc. of SME-AIME Annu. Fall Meeting, St. Louis, MO, Sept. 7–10,

1986). Soc. Min. Eng. AIME, Littleton, CO, 1986, pp. 3–8. It has been found that lithological conditions over the Pittsburgh Coalbed cause the subsidence coefficient to vary within the area of the subsidence trough. This precludes the use of European-developed predictive models, which are based upon a constant subsidence coefficient. Regression analysis of the distribution of subsidence coefficients from 11 Bureau of Mines, U.S. Department of the Interior, longwall panel studies on the location relative to the edge of the panel has yielded a third degree polynomial equation. This equation has been incorporated into a BASIC computer program for use on a personal computer that allows users with no previous knowledge of the theory of subsidence to predict vertical movements over typical longwall panels in the Northern Appalachian Coal Basin.

OP 141–86. Column Flotation of Montana Chromite Ore, by J. D. McKay, D. G. Foot, Jr., and J. L. Huiatt. Miner. and Metall. Process., Aug. 1986, pp. 170–177. The U.S. Bureau of Mines compared column flotation using either fine or coarse bubbles with conventional flotation on a Montana chromite ore. On deslimed ore, fine-bubble column flotation produced a 44.7% Cr_2O_3-grade rougher concentrate with 87% recovery, compared with 43.8% and 43.5% Cr_2O_3-grade rougher concentrates with 85% and 77% recovery for coarse-bubble column flotation and conventional flotation, respectively. On undeslimed ore, coarse-bubble and fine-bubble column flotation produced rougher concentrates containing approximately 41.5% Cr_2O_3 with 95% recovery, exceeding conventional flotation, which produced 35.6% Cr_2O_3-grade concentrates with 87% recovery.

OP 142–86. Mining for Lunar Base Support, by E. R. Podnieks and W. W. Roepke. Sec. in Ch. 7, Lunar Materials and Processes, in Lunar Bases and Space Activities of the 21st Century, ed. by W. W. Mendell. Lunar and Planet. Inst., Houston, TX, 1985, pp. 445–452. Mining and excavation technologies must be developed for the establishment of lunar bases that are capable of operating under the severe conditions of the lunar environment. The mining technology research needs for establishing a permanent lunar base utilizing lunar resources are outlined and briefly discussed in this paper. These requirements range from initial exploration needs to those required for gradually reaching full lunar base autarky. The extraterrestrial mining and excavation needs indicate that a multidisciplinary research effort must be initiated early in the lunar base program to provide timely research results for the subsequent development stages.

OP 143–86. Measurement and Analysis of Foundation Tilt Resulting From Mine Subsidence in Southern Illinois, by Larry R. Powell, Theodore L. Triplett, and Ronald E. Yarbrough. Paper in Proceedings of the Second Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9–11, 1986, pp. 142–152. The Bureau of Mines, in cooperation with the Illinois Mine Subsidence Insurance Fund, monitored the response of two foundations to ground movements induced by subsidence from high extraction mining in southern Illinois. The objectives of the monitoring program were to study the interaction between the ground surface and a foundation during a subsidence event and to determine the capability of the tiltmeter to detect and monitor subsidence movements. This paper describes the monitoring instrumentation and techniques as they relate to the mining and site conditions, and the capability of a tiltmeter to detect and follow the tilt of the foundations is also demonstrated.

OP 144–86. Electrochemical Determination of Thermodynamic Properties and X-Ray Diffraction Investigation of the Fe_3O_4-$ZnFe_2O_4$, by S. C. Schaefer and R. A. McCune. Metall. Trans. B, v. 17B, Sept. 1986, pp. 515–521. This paper describes the Bureau of Mines investigation into the thermodynamic properties of the Fe_3O_4-$ZnFe_2O_4$ solid solutions. Activities of Fe_3O_4 (magnetite) in solid solutions were determined with high-temperature electromotive force cells using stabilized ZrO_2 (zirconia) as the solid electrolyte. Partial and integral molar properties were derived for the Fe_3O_4-$ZnFe_2O_4$ system, and lattice parameter measurements of the Fe_3O_4-$ZnFe_2O_4$ solid solutions show a positive deviation from Vegard's law.

OP 145–86. Remote Mining Using Water for Ground Support, by Robert L. Schmidt and George A. Savanik. Paper in Proceedings of Fifth Conference on Ground Control in Mining, Morgantown, WV, June 11–13, 1986, ed. by A. Wahab Khair and Syd S. Peng. WV Univ., 1986, pp. 89–106. This paper examines the role of water as a ground support medium as demonstrated by Bureau of Mines research on borehole mining of phosphate in St. Johns County, FL. A borehole mining tool incorporating a water jet nozzle and slurry eductor in a single downhole tool, and lowered through a borehole into the ore zone, eroded an underground cavity by the action of the water jet, simultaneously pumping the slurry to the surface. In addition to phosphate mining, the system has been sucessfully used in mining coal, oil sand, and uranium.

OP 146–86. Simple, Low-Cost Planar Flow Casting Machine for Rapid Solidification Processing, by M. T. Smith and M. Saletore. Rev. Sci. Instrum., v. 57, No. 8, Aug. 1986, pp. 1647–1653. This paper describes the design, fabrication, and operation of a relatively simple low-cost planar flow casting (PFC) machine optimized for small-batch processing. Several design features found beneficial to PFC process operation include (1) a ground nozzle stopper to retain the alloy charge during melting, (2) a remote, large-volume pressure vessel connected to the crucible gas system to reduce temperature-induced pressure fluctuations, and (3) the use of a nested induction coil that allows both the melt charge and the crucible reservoir to be located close to the cooling wheel. The results of several PFC process runs are provided showing typical values of the cooling wheel surface velocity, crucible ejection pressure, and crucible nozzle clearance gap. Examination of the rapidly solidified, Fe-based ribbons for thickness, dimensional uniformity, and atomic structure indicated that good quality glassy ribbon could be produced with proper selection of the controllable process variables. In addition, single-variable linear regression analysis was used to determine the effect of each process variable on the resulting ribbon thickness.

OP 147–86. Evaluation of Electrogalvanized Deposits From Zinc Wastes, by Vijay Srinivasan and Thomas J. O'Keefe. Ch. 47 in Zinc '85, ed. by K. Tozawa (Proc. of International Symposium on Extractive Metallurgy of Zinc, Tokyo, Japan, Oct. 14–16, 1985). Min. and Metall. Inst. Japan, Tokyo, Japan, 1985, pp. 749–762. This paper describes the preliminary testing of various electrolytes made from waste materials using a range of processing conditions. Primary processing variables included acid concentration, steel substrate preconditioning, and electrolytic cell type. For comparison, deposits were also made from solutions prepared using french process zinc oxide. The morphology of the coatings was examined using scanning electron microscopy techniques.

OP 148–86. Wear of 12 Alloys During Laboratory Milling of Phosphate Rock in Phosphoric Acid Waste Water, by J. H. Tylczak, D. J. Singleton, and R. Blickensderfer. Miner. and Metall. Process., Aug. 1986, pp. 187–190. As part of its research on the wear of mining and mineral processing equipment, the U.S. Bureau of Mines evaluated the erosion-corrosion characteristics of 12 alloys in phosphoric acid waste water. Tests were conducted on 2- and 5-cm-diam specimens in 12- and 60-cm-diam ball mills by grinding phosphate rock in gypsum pond water with an initial pH of 1.6. For comparison, grinding tests also were conducted in tap water. Static corrosion tests in gypsum pond water also were carried out. For all alloys tested, the wear by erosion-corrosion was greater than the sum of erosion plus static corrosion. A low-alloy, high-carbon steel and a high-manganese, nitrated stainless steel were the most cost-effective materials.

OP 149–86. Hydrophobic Effects of Sulfur and Xanthate on Metal and Mineral Surfaces, by G. W. Walker, C. P. Walters, and P. E. Richardson. Int. J. Miner. Process., v. 18, 1986, pp. 119–137. The hydrophobic character of a variety of base-metal sulfides and gold has been examined in the presence of sodium hydrosulfide and potassium ethylxanthate. The degree of hydrophobicity induced by electrodeposition of sulfur and by electrochemical reaction between the minerals and

ethylxanthate were determined by contact-angle measurements on polished surfaces and by flotation of mineral particles. During flotation, mineral-reagent interactions were followed by monitoring the solution composition spectrophotometrically. Results have shown that on gold and chalcopyrite the oxidation of hydrosulfide to molecular sulfur and the oxidation of ethylxanthate to dixanthogen produced hydrophobic surfaces; on pyrite, sulfur deposition was more effective than dixanthogen in producing a hydrophobic surface. Chalcocite, in contrast to gold, chalcopyrite, and pyrite, was found to react directly with ethylxanthate and hydrosulfide, but only the metal xanthate product was hydrophobic.

OP 150–86. A Case Study of Water Level Fluctuations Over a Series of Longwall Panels in the Northern Appalachian Coal Region, by J. S. Walker, J. B. Green, and M. A. Trevits. Paper in Proceedings of the Second Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9–11, 1986, pp. 264–269. This paper describes an investigation of water level fluctuation in five wells positioned over three consecutively mined longwall panels that was initiated in conjunction with an intensive subsidence monitoring program. The purpose of this work was to provide detailed information which could be used to predict certain hydrologic effects of longwall mining in the Northern Appalachian Coal Region. The results of this case study indicate that water level fluctuations in the local ground water system above longwall panels is associated with subsidence and that the static level will generally reestablish at or near the pre-mining elevation after mining is completed.

OP 151–86. The Molten Cyanide System for Electrodeposition of the Platinum-Group Metals, by Richard P. Walters and David R. Flinn. Paper in Precious Metals 1986, ed. by U.V. Rao (Proc. of the Tenth International Precious Metals Institute Conference, Lake Tahoe, NV, June 7–13, 1986). Int. Precious Met. Inst., 1986, pp. 439–443. Over the last two decades the Bureau of Mines had conducted several studies of the electrodeposition of platinum-group metals from a molten alkali metal cyanide bath. Bureau research has focused on producing platinum-group metal coatings on refractory metals and on more common structural materials. This research has shown that high-quality thick, adherent, and coherent deposits can be prepared. The methods used for electrolyte preparation, the parameters important in the deposition process, and some of the physical properties of the platinum coatings produced are presented in this paper. For in-depth discussions of specific topics, a bibliography of Bureau research is also included.

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INFORMATION CIRCULARS

IC 9085. Columbium Availability—Market Economy Countries. A Minerals Availability Appraisal, by Frederick W. Miller, R. J. Fantel, and D. A. Buckingham. 1986. 20 pp. 17 figs. The Bureau of Mines has investigated the availability of columbium from 19 deposits (3 producers and 16 nonproducers) in 7 market economy countries (MEC's). Brazil has the largest recoverable columbium resource, possessing approximately 2.39 million metric tons (Mmt), or 69 pct of the MEC total (3.47 Mmt). The Western Hemisphere countries of Brazil, Canada, and the United States contain 3.14 Mmt of recoverable columbium or 90 pct of the MEC total. Columbium recovered as a byproduct of tin mining is not included as part of MEC resources in this study. Currently producing mines are Araxa and Catalao in Brazil, and Niobec in Canada. These three mines have 2.42 Mmt of recoverable resources or approximately 69 pct of the MEC total. It is estimated that these mines, operating at full capacity, could satisfy cumulative MEC demand (based on an annual growth rate of 5.1 pct) for the next 20 yr. The United States is totally dependent upon foreign sources for its columbium supply. The majority of U.S. columbium is imported from Brazil in the form of steelmaking-grade ferrocolumbium. Canada has been the sole source of pyrochlore concentrates since Brazil discontinued exports in 1981. The United States also imports small (but important) quantities of columbium as columbite concentrates from Nigeria and Brazil, as columbite contained in tin slags from Thailand and Malaysia, and as synthetic concentrates from the Federal Republic of Germany.

IC 9096. Analyses of Natural Gases, 1985, by B. J. Moore and Stella Sigler. 1986. 182 pp. 1 fig. This publication contains analyses and related source data for 517 natural gas samples from 25 States and 1 foreign country. Of the total samples, 298 were collected during calendar year 1985; the remainder were collected earlier, but releases granting permission to publish were not received before 1985. All samples were obtained and analyzed as part of Bureau of Mines investigations of the occurrences of helium in natural gases of countries with free market economies. This survey has been conducted since 1917. The analyses published herein were made by mass spectrometer and chromatograph.

IC 9098. Antimony Availability—Market Economy Countries. A Minerals Availability Appraisal, by C. M. Palencia and C. P. Mishra. 1986. 20 pp. 8 figs. The Bureau of Mines studied the potential availability of primary antimony (Sb) from demonstrated resources in 21 mines and deposits in market economy countries (MEC's). Twelve of these properties were evaluated as producers and nine as nonproducers. The 21 studied properties contain 499,600 mt Sb as demonstrated resources, of which 304,000 mt is recoverable as antimony metal; another 973,500 mt Sb is contained in inferred resources. Recoverable antimony from demonstrated U.S. deposits is only 10,700 mt, just 3.5 pct of the MEC total. Domestic production of primary antimony from operating mines has averaged only 561 mt/yr over the 10-yr period 1975–84. This represents just over 5 pct of total U.S. consumption of primary antimony, which averaged 11,081 mt/yr during the same period. The United States will thus continue to rely on imported ores and/or concentrates, antimony oxides, and metal to satisfy domestic industrial requirements. At production costs up to $1.15/lb Sb, 110,000 mt of refined antimony is potentially available from 10 of the 21 studied properties. At $2/lb, 294,000 mt Sb is available, and at $3/lb, the total rises to 304,000 mt Sb available from all evaluated producers of refined antimony.

IC 9100. Beryllium Availability—Market Economy Countries. A Minerals Availability Appraisal, by Audrey A. Soja and Andrew E. Sabin. 1986. 19 pp. 16 figs. The Bureau of Mines investigated beryllium resources, production methods, and production costs to estimate the quantity of beryllium available for future use. Eight mining districts and 12 deposits are included in the study; lack of data precluded the evaluation of resources from 6 nonproducing and undeveloped deposits. The study revealed that demonstrated beryllium-bearing resources should be sufficient to meet domestic needs and those of other market economy countries (MEC's) well into the 21st century. Total demonstrated beryllium-bearing in situ resources from MEC's are estimated at 118 million metric tons (Mmt) of ore containing approximately 33,000 mt beryllium metal. Approximately 111 Mmt ore containing 29,000 mt beryllium was included in the cost analysis and availability sections of this study. Three Brazilian districts currently produce beryl ore, and one domestic company, Brush Wellman Inc., produces bertrandite ore. Brush Wellman Inc. owns and operates the only MEC facility in the Western Hemisphere for extracting beryllium values from beryl and bertrandite and is the beryllium industry's only fully integrated corporation.

IC 9103. Uranium Occurrences in the Northern Darby Mountains, Seward Peninsula, AK, by Jeffrey Y. Foley and James C. Barker. 1986. 27 pp. 13 figs. In 1980, the Bureau of Mines investigated the northern Darby Mountains on the Seward Peninsula, AK, for radioactive mineral deposits. Uranium is concentrated in silicified shear zones in biotite quartz monzonite of the Darby pluton. The shear zones are best exposed in steep, narrow, avalanche gullies; they are characterized by radiometric anomalies and by uranium and thorium geochemical anomalies. Radiometric and geochemical anomalies are also found over altered biotite quartz monzonite where there are no visible shear zones. The radiometric and uranium anomalies are often spatially, but apparently not genetically, associated with alkaline mafic and felsic dikes. Similar geochemical and radiometric anomalies over disclosed altered zones and geochemical anomalies in sediments downstream from the altered zones indicate that additional areas may also be favorable targets for uranium deposits. Analyses of panned, heavy mineral concentrates show no significant concentrations of uranium or thorium in resistant heavy minerals. This indicates that radioactive elements in the Darby pluton are concentrated in soluble, nonresistant minerals that may constitute a recoverable uranium resource.

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IC 9104. Tin Reconnaissance of the Kanuti and Hodzana Rivers Uplands, Central Alaska, by James C. Barker and Jeffrey Y. Foley. 1986. 27 pp. 13 figs. The Bureau of Mines evaluated the tin development potential of the uplands between the Kanuti and Hodzana Rivers from 1978 through 1980. Chemical and petrologic data indicate that local granitic intrusions are generally similar to "tin granites" that contain tin deposits elsewhere. The tin mineral cassiterite (SnO_2) was identified in chlorite-rich greisen from the Sithylemenkat pluton. Greisen zones are located near the intersections of high-angle, linear structural features, and samples contain up to 0.23 pct Sn. One bedrock exposure of greisen is 10 to 15 ft wide. Although some lode mineralization is present, the deeply eroded nature of the region suggests larger tin-bearing cupolas may have existed prior to erosion. Extensive stream gravel deposits have not been affected by glaciation, and potential exists for placer tin deposits. Especially favorable is a large semiclosed basin drained by the Kanuti Kilolitna River. Heavy mineral concentrates collected from surface alluvium in the Kanuti Kilolitna River valley contained up to 51.2 pct Sn (0.02 to 0.4 lb/yd^3 Sn), up to 5 pct W, up to 0.4 pct Cb(Nb), and up to 0.1 pct Ta. The concentration of heavy minerals is expected to increase with depth. Detailed mapping and extensive surface and subsurface sampling will be needed to quantify the mineral development potential of the lode and placer tin deposits in the uplands.

PREPRINTS FROM MINERALS YEARBOOK, 1985

These preprints are chapters from Minerals Yearbook, 1985. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

Aluminum, by Frank X. McCawley. 24 pp.
Bauxite and Alumina, by Luke H. Baumgardner and Ruth A. Hough. 13 pp.
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Sand and Gravel, by Valentin V. Tepordei. 15 pp. 2 figs.
Titanium, by Langtry E. Lynd and Ruth A. Hough. 15 pp.
Vermiculite, by A. C. Meisinger. 4 pp.

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TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 70–86. Maps Summarizing Land Availability for Mineral Exploration and Development in North-Central Alaska, 1985, by Robert G. Bottge. May 27, 1986. 14 maps. These maps show land within 14 Alaskan quadrangles (Bettles, Beaver, Fort Yukon, Black River, Tanana, Livengood, Circle, Charley River, Kantishna, Fairbanks, Big Delta, Eagle, Mount McKinley, and Tanacross) that was open to mineral exploration as of July 1, 1985. As many as 15 other land subclassifications are depicted, as well as restrictions, private lands, and land closed to mining. The mineral deposits plotted are based on the Bureau of Mines Minerals Availability System (MAS). Included are tables keyed to deposit numbers within each quadrangle identifying one or more mineral deposits within a 3-mile radius. The table also includes the MAS sequence number (to relate it to Bureau files), major commodities associated with the deposit,

and an indicator of past production. Available for reference at AFOC/A, AFOC/F, and AFOC/J. Copies of these maps will not be available for purchase.

OFR 71–86. Maps Summarizing Land Availability for Mineral Exploration and Development in South-Central Alaska, 1985, by Robert G. Bottge. May 27, 1986. 21 maps. These maps show land within 20 Alaskan quadrangles (Healy, Mount Hayes, Talkeetna Mountains (2 maps), Gulkana, Nabesna, Lime Hills, Tyonek, Anchorage, Valdez, McCarthy, Lake Clark, Kenai, Seward, Cordova, Bering Glacier, Iliamna, Seldovia, Blying Sound, Middleton Island, and Icy Bay) that was open to mineral exploration as of July 1, 1985. As many as 15 other land subclassifications are depicted, as well as restrictions, private lands, and land closed to mining. The mineral deposits plotted are based on the Bureau of Mines Minerals Availability System (MAS). Included are tables keyed to deposit numbers within each quadrangle identifying one or more mineral deposits within a 3-mile radius. The table also includes the MAS sequence number (to relate it to Bureau files), major commodities associated with the deposit, and an indicator of past production. Available for reference at AFOC/A, AFOC/F, and AFOC/J. Copies of these maps will not be available for purchase.

OFR 87–86. Summary of Surface Testing of the Umbrella Miner Concept and First Prototype Machine, by Richard B. Farrar. July 1986. 11 pp. The umbrella miner, a prototype continuous mining machine for simultaneous mining and bolting in a room-and-pillar coal mine, was designed and fabricated. This machine was tested on the surface at the Pittsburgh Research Center's mine equipment test facility during an 18-month period from September 1984 through February 1986. Surface testing of the umbrella miner first prototype unit showed the concept to have considerable potential for fulfilling the industry need for a mining machine that can simultaneously mine coal, bolt roof, and advance continuously from "break to break." However, a second-generation machine would have to be designed, fabricated, and tested before that potential could be realized. The first prototype umbrella miner, a highly experimental machine, experienced several major problems during surface testing. Chief among these were the inability to tram and maneuver dependably, the inconsistent operation of the hydraulically powered functions because of the complexity of the hydraulic system, and unreliability of the gathering head conveyor. Research was done under contract J0133926 by Fairchild International, Inc. Available for reference at ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 87–105789; paper copy price code A02. $9.95.

OFR 90–86. Coal Injection in an Experimental Blast Furnace: A Comprehensive Report, by Philip L. Woolf. Aug. 1985. 58 pp. 6 figs. Blast furnace coal injection tests conducted by the Bureau of Mines in cooperation with a consortium of 22 steel companies in 1963–64 are described. These tests were part of a program of extensive investigation of auxiliary fuel injection in the Bureau's experimental blast furnace located at Bruceton, PA. Seventeen coal tests are described on various coals ranging from anthracite to subbituminous. Factors affecting maximum rates of the injection were studied. These included coal size, coal type, and oxygen enrichment. The effect of high sulfur content coal and the means to control metal sulfur were investigated. An epilogue briefly describing the commercial experience with coal injection from 1960 to the present has been included. Research was done under contract J0134049 by Philip L. Woolf. Available for reference at AD/MMR, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 87–111159; paper copy price code A04. $13.95.

OFR 93–86. Monitoring Moisture Migration in the Vadose Zone Using Electrical Resistivity Techniques, by M. J. Waller, W. F. Kean, and H. R. Layson. Jan. 1986. 94 pp. 47 figs. Surface resistivity techniques were used at four field sites to monitor changes in apparent resistivities with variations in soil moisture content in the vadose zone. Apparent resistivity values were correlated with gravimetric moisture contents from soil samples taken at each site. Tensiometer readings were taken at two sites and correlated with the results of gravimetric moisture contents and apparent resistivities. Moisture at two of the sites was added by extensive watering; rainfall events were monitored at the other two sites. A recharge event at a dewatering program was monitored at a fifth site. A Ghosh-Koefed multilayer computing algorithm was used to derive true resistivities from bulk or apparent resistivities. An automated data acquisition system was developed to measure resistivity changes and to process the data in the field. These studies are the first to evaluate measurement of moisture migration in clay rich soils using surface resistivity techniques. Results indicate that surface resistivity techniques readily measure changes in moisture contents in the vadose zone in clay rich soils. Correlation of apparent and true resistivity values with gravimetric moisture contents is more complex and requires additional research. Research was done under contract H0245004 by EarthTech, Inc. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 87–117842; paper copy price code A05. $13.95.

OFR 94–86. Hydrologic Properties and Characteristics of Two Tailings Ponds, by R. L. Hoye and W. E. Thompson. Jan 1986. 163 pp. 72 figs. This report describes site investigations conducted at two tailings impoundments to develop baseline hydrological data for the evaluation of these waste management practices. The impoundments are associated with a lead mine and mill in Missouri and a gold mine and mill in South Dakota. The overall objectives of the investigations were to estimate the rate of seepage, to evaluate water quality impacts, and to obtain a better definition of the hydrogeology in the immediate area of the dams. Water table contour maps were prepared, water balance calculations were made, pump tests were conducted, water quality samples were collected and analyzed, and pertinent existing data were assembled and evaluated. Results of the study were largely inconclusive with regard to determination of water quality impacts due to seepage and estimation of theoretical seepage rates by water balance calculation. They have, however, provided additional insight into understanding the complex hydrogeological systems at these sites. Research was done under contract H0222003 by PEI Associates, Inc. Available for reference at AD/MR and SRC. Copies of this report will not be available for purchase.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 31–86. Mineral Resources of the Sheldon Contiguous Study Area, Washoe County, Nevada, by Leon E. Esparza. 1986. 9 pp. 3 figs. Western Field Operations Center, Spokane, WA.

MLA 47–86. Mineral Resources of the Providence Mountains Study Area, San Bernardino County, California, by Phillip R. Moyle, Jerry E. Olson, and Richard S. Gaps. 1986. 306 pp. 65 figs. Western Field Operations Center, Spokane, WA.

MLA 60–86. Mineral Resources of the East Fork High Rock Canyon Study Area, Humboldt and Washoe Counties, Nevada, by Steven W. Schmauch. 1986. 9 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 62–86. Mineral Investigation of a Part of the Signal Mountain Wilderness Study Area (AZ–020–138), Maricopa County, Arizona, by Terry J. Kreidler. 1986. 9 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

MLA 63–86. Mineral Resources of the Sheep Creek West Wilderness Study Area, Owyhee County, Idaho, by Phillip R. Moyle and Alan R. Buehler. 1986. 11 pp. 2 figs. Western Field Operations Center, Spokane, WA.

MLA 64–86. Mineral Investigation of a Part of the Cactus Plain Wilderness Study Area (AZ–050–014A/B), La Paz County, Arizona, by Terry J. Kreidler. 1986. 11 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.

MLA 65–86. Mineral Investigation of a Part of the Dominguez Canyon Wilderness Study Area (CO–070–150), Delta, Mesa, and Montrose Counties, Colorado, by Russell A. Schreiner. 1986. 13 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MINERAL INSTITUTES REPORTS

The mineral institutes program operates under Public Law 98–409 and under title III of Public Law 95–87. It is designed to improve the quality of mineral engineering research and education through support for research in mining, metallurgical processing, and related mineral sciences. The Bureau of Mines supports this research through annual allotment grants, matched by non-Federal funds, to mineral institutes at 31 universities throughout the United States, and by research grants to these institutions to address specific mining and processing problem areas.

The following reports describe research conducted under research grants. Individual copies may be available from the authors of the papers at the university cited. Copies of these reports are NOT available from the Bureau of Mines.

MIR 7–86. A Study of Roof Caving in the Eastern U.S. Coalfields, by Z. Agioutantis and M. Karmis. Paper in Proceedings of 5th Conference on Ground Control in Mining, Morgantown, WV, June 11–13, 1986, ed. by A. Wahab Khair and Syd S. Peng. WV Univ., 1986, pp. 134–146. This report describes caving and mass deformation characteristics above longwall panels including the effects of geological and geomechanical characteristics of the strata on the caving height and the bulking of the caved material, testing of the applicability of the various theoretical and empirical models of roof caving, and formulation of a numerical ground deformation model for nonelastic material behavior. This research was done under grant G1125151–5109 at the Virginia Polytechnic Institute and State University.

MIR 8–86. Temperature and Time Effects on the Closure of a Gravel Room in Permafrost, by Scott L. Huang. Bull. Assoc. Eng. Geol., v. 22, No. 1, Jan. 1985, pp. 53–65. Underground excavations in arctic and subarctic regions are subject to significant creep deformation, which are highly temperature and time dependent. The U.S. Army Cold Regions Research and Engineering Laboratory permafrost tunnel was monitored to investigate these dependencies. The creep behavior of the gravel room was described by a combined exponential and power relationship between closure rate, time factor, and ground temperature. For the long-term stability of an underground opening in frozen ground, the time effect upon the closure rate is secondary to the influence of temperature. The strata separation in the gravel roof of the tunnel opening was also studied. The partings were observed only during periods of high temperature and closure. The results of the study suggest that after consideration of factors such as ground temperature and time dependency, underground chambers in permafrost can be designed and utilized for long-term applications. This research was done under grant G1125151–0202 at the University of Alaska at Fairbanks.

MIR 9–86. Stability Study of CRREL Permafrost Tunnel, by Scott Lin Huang, Nolan B. Aughenbaugh, and Ming-Chee Wu. J. Geotech. Eng., v. 112, No. 8, Aug. 1986, pp. 777–790. This paper summarizes the results of a research project conducted at the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) permafrost tunnel. The relationships between the ground temperature, the roof span dimensions, and the vertical convergence rate of the CRREL tunnel correlate with a combined exponential and logarithmic model. The continuous deformation of the tunnel was primarily temperature dependent. In addition to the effect of temperature, the opening width also exhibited a strong influence on tunnel deformation. The span length gradually achieved a constant effect upon tunnel deformation as the opening width increased. The overburden thickness also exhibited an influence on convergence rate. This research was done under grant G1125151–0202 at the University of Alaska.

MIR 10–86. Estimation Practices for Reserves of Gold Deposits, by B. L. Kwa and P. Mousset-Jones. Paper in Proceedings of the Mining Latin America Conference, Santiago, Chile, Nov. 17–19, 1986. Inst. Min. Metall., 1986, pp. 201–219. This paper describes the problems mining and exploration companies have in estimating precious metal deposits, based on a questionnaire soliciting information on drill-hole spacing, mineral reserve estimation methods used, and sampling and assaying practices, as well as exploring the early investigative and defining stages of the industry. This research was done under grant G1125151–3252 at the University of Nevada—Reno.

MIR 11–86. Indicator Kriging Applied to a Gold Deposit in Nevada, U.S.A., by Boo Leong Kwa and Pierre Mousset-Jones. Paper in Ore Reservation Estimation Methods, Models, and Reality, ed. by M. David, R. Froidevaux, A. J. Sinclair, and M. Vallee (Proc. Symp., Montreal, Quebec, May 10–11, 1986). Can. Inst. Min. Metall., 1986, pp. 185–194. This report describes a case study utilizing geostatistical techniques carried out using ordinary linear kriging and indicator kriging. Blast hole data from seven benches of the Vantage One open pit of the Alligator Ridge Mine were used. In addition, indicator variants of the moving window and inverse distance weighting methods were also used. Generally, the indicator methods were found to have worked very well, with errors of 5 pct or less when estimated recoveries were compared with production figures. This research was done under grant G1125151–3252 at the University of Nevada—Reno.

MIR 12–86. A Comparison of Methods To Characterize Unsaturated Hydraulic Properties of Mill Tailings, by Mark B. Larson and Daniel B. Stephens. Paper in Proceedings of the Seventh Symposium on Management of Uranium Mill Tailings, Low-Level Waste and Hazardous Waste, Fort Collins, CO, Feb. 6–8, 1986, pp. 335–346. The purpose of this report is to discuss the results of extensive analyses on copper mill tailings sands to characterize saturated and unsaturated hydraulic conductivity and water content-pressure head relationships. These tailing characteristics were determined using various empirical methods, theoretical models, laboratory techniques, and field procedures. This research was done under grant G1125132–3202 at the New Mexico Institute of Mining and Technology.

MIR 13–86. Removal of Arsenic From Lead Smelter Speiss, by M. Peterson and L. G. Twidwell. J. Hazard. Mater., v. 12, 1985, pp. 225–229. This report describes the removal of arsenic from lead smelter speiss by volatilization techniques. This research was done under grant G1125132–3002 at the Montana College of Mineral Science and Technology.

MIR 14–86. Stability of Mineral Suspensions in the Absence and Presence of Collectors, Dispersants and Flocculants, by Z. Sadowski and R. W. Smith. Miner. and Metall. Process., Nov. 1985, pp. 217–222. The stabilities of finely divided mineral suspensions were determined as functions of pH and concentrations of polyethylene oxide, sodium ligninsulfonate, sodium dodecylsulfate, and sodium oleate. In addition, the electrokinetic potentials of the minerals were determined under identical pH and additive concentration conditions. Flocculation or dispersion of the suspensions is discussed in terms of both the amount and manner of adsorption at the appropriate solid-liquid interface as it is influenced by additive concentration and pH. This research was done under grant G1125132–3201 at the University of Nevada—Reno.

MIR 15–86. Electrokinetic Study of the Role of Modifying Agents in Flotation of Salt-Type Minerals, by R. W. Smith and David Shonnard. Am. Inst. Chem. Eng. J., v. 32, No. 5, May 1986, pp. 865–868. This report describes an investigation in elucidating, via an electrophoresis study, the role of sodium carbonate and lignin sulfonate in salt-type flotation separation. The assessment of the role of rare-earth ions potentially dissolved from bastnaesite is also discussed. This research was done under grant G1123132–3201 at the University of Nevada—Reno.

III. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 11–86. A Novel Technique for the Recovery of Coarse North Carolina Phosphate, by B. E. Davis, T. O. Llewellyn, and G. V. Sullivan. Soc. Min. Eng. AIME preprint 85–331, 1985, 6 pp; Miner. and Metall. Process., v. 3, No. 3, Aug. 1986, pp. 198–200. A technique was devised by the Bureau of Mines to recover coarse (plus 1.2 mm) North Carolina phosphate now discarded as waste. Concentration utilizes the difference in particle sphericity between the relatively flat calcite and the rounded phosphate pebbles. Sizing, treatment in a continuous hydraulic classification system, and grinding upgraded a 17.0-pct-P_2O_5 reject to 24.5 pct P_2O_5, with a phosphate recovery of 63 pct.

OP 119–86. Longwall Shearer Performance Using Water-Jet-Assisted Cutting, by C. D. Taylor, P. D. Kovscek, F. N. Kissell, and E. D. Thimons. Paper in Proceedings of Longwall USA Conference, Pittsburgh, PA, June 24–26, 1986, pp. 233–256; Paper in the Proceedings of the 8th International Symposium on Jet Cutting Technology, Durham, England, Sept. 9–11, 1986. BHRA, Cranfield, Bedford, England, 1986, pp. 93–102. The U.S. Bureau of Mines equipped a longwall shearer with a water-jet-assisted mechanical cutting system to determine the effect of the high-pressure sprays on machine performance, airborne dust levels generated, and size of particulates formed. Testing was conducted on a simulated coal block (coalcrete) while cutting at a water pressure of 190 psi and at water-jet-assisted pressures ranging from 1,000 to 6,000 psi. The shearer motor energy used by the shearer during cutting coalcrete was determined for each cutting condition. Results indicate that the motor energy required by the shearer for each ton of material cut did not vary significantly as the water pressure was increased. Results of dust measurements recorded near the cutting drum indicate that at water pressures above 3,000 psi, dust reductions up to 85 pct were achieved compared with cutting with conventional sprays. Analysis of the particulate size distribution formed during cutting showed that increasing the water pressure resulted in increased median particle size. In light of these results, various mechanisms for water-jet-assisted cutting are discussed.

OP 152–86. U.S. Surface Coal Mine Mobile Equipment: Operator Noise Exposures and Noise Controls, by Roy C. Bartholomae and J. Alton Burks. Paper in Proceedings of the International Conference on the Health of Miners, Pittsburgh, PA, June 2–7, 1985, ed. by Robert W. Wheeler. Am. Conf. of Gov. Ind. Hyg., Cincinnati, OH, v. 14, 1986, pp. 575–590. The reduction of the noise exposure of operators of mobile surface mine equipment has been a primary objective of the Bureau of Mines. Approximately 25,000 mobile equipment operators in U.S. surface mines (45% of the operators) are overexposed to noise. These mobile machines include bulldozers, front-end loaders, haulers, shovels, draglines, trucks, scrapers, drills, and motor graders. Bulldozers and front-end loaders cause about two-thirds of the noise overexposures. The most cost-effective operator noise exposure control was determined to be acoustical cabs.

OP 153–86. Noise-Induced Hearing Loss—A Review, by Roy C. Bartholomae and Gerald W. Redmond. Paper in Proceedings of the International Conference on the Health of Miners, Pittsburgh, PA, June 2–7, 1985, ed. by Robert W. Wheeler. Am. Conf. of Gov. Ind. Hyg., Cincinnati, OH, v. 14, 1986, pp. 41–61. This paper provides an in-depth discussion on the ear and hearing loss, including references to many documented studies showing the deteriorative effects of high noise levels, and an in-depth discussion of the background and concept of the noise exposure damage risk criteria and noise dose, which takes into effect noise levels and exposure times. Also discussed are the United States federal noise regulations pertaining to mining, the occupational noise problem (including references estimating that the future hearing-related compensations to U.S. workers will range from $3.4 billion to $20 billion), and the Bureau of Mines approach to mining noise control.

OP 154–86. Pitzer-Debye-Hückel Limiting Slopes for Water From 0° to 350° C and From Saturation to 1 kbar, by R. P. Beyer and B. R. Staples. J. Solution Chem., v. 15, No. 9, 1986, pp. 749–764. Using internationally recognized critical evaluations for the dielectric constant of water by Uematsu and Franck and the thermodynamic surface of water by Haar, Gallagher, and Kell, this paper presents values for the Pitzer-Debye-Hückel limiting slopes for osmotic coefficients, apparent molal enthalpies, apparent molal heat capacities, apparent molal volumes, molal compressibilities, and apparent molal expansivities from 0° to 350° C and from saturation to 1 kbar.

OP 155–86. Predicting Head Loss for Chunk Coal Slurry Transport, by Robert L. Cardenas, Mackenzie Burnett, and Anthony M. Briscoe. Paper in Advancements in Aerodynamics, Fluid Mechanics, and Hydraulics, ed. by R. E. A. Arndt, H. G. Stefan, C. Farell, and S. M. Peterson (Proc. of Specialty Conference of the Aerospace, Engineering Mechanics, and Hydraulics Divisions of the American Society of Civil Engineers, Minneapolis, MN, June 3–6, 1986). Am. Soc. of Civ. Eng., New York, NY, 1986, pp. 473–480. During research performed under a Bureau of Mines contract to develop a coarse coal injector, hydraulic transport data were gathered on pipeline head loss. These data have since been used to develop a combined sliding bed and heterogeneous flow model for predicting coarse (chunk) coal slurry head loss.

OP 156–86. The Vanadium-Nitrogen System: A Review, by O. N. Carlson, J. F. Smith, and R. H. Nafziger. Metall. Trans. A, v. 17A, Oct. 1986, pp. 1647–1656. This paper is a critical review of the available phase equilibria, crystallographic, and thermodynamic data for the vanadium-nitrogen system. Three nitride phases been identified and their crystal structures, ranges of homogeneity, and melting or decomposition temperatures determined. The solvus boundary for the vanadium-rich solid solution is placed at 3.8 at. pct N at 550° C and increases to 11 at. pct N at 1,500° C. A break in the solvus observed at 550° C is associated with the formation of a metastable phase, $V_{16}N$. Other metastable phases have been identified, but their exact stoichiometries and structures have not been unambiguously determined. The enthalpies and free energies of formation, heat capacities, and dissociation pressures for the subnitride and mononitride were evaluated and correlated.

OP 157–86. China, by E. Chin. Sec. in Mining Annual Review 1986, pp. 351–360. This article presents data on the minerals industry of China covering the shift from Government ownership to public ownership and its effect on production and trade in that country. Also included is a commodities review of metals, nonmetals, and fuels.

OP 158–86. Effects of Posture on Back Strength and Lifting Capacity, by Sean Gallagher and Thomas G. Bobick. Paper in Proceedings of The Human Factors Society 30th Annual Meeting, Dayton, OH, Sept. 29–Oct. 3, 1986, pp. 234–238. This paper describes a Bureau of Mines pilot study examining the effects of posture on back strength and maximum

acceptable weight of lift (MAWL) on six healthy male subjects. Six back strength measurements (three static and three dynamic) were made while the subjects were kneeling and standing. In addition, these subjects (who were unaccustomed to lifting in these postures) volunteered to participate in a study of psychophysically determined MAWL in both postures. Results of the back strength tests showed a significantly lower peak torque per body weight output in kneeling versus standing back strength measurements for five out of six test comparisons. Subjective estimates of lifting capacity in the kneeling posture were significantly lower than those for the stooped posture. The results of tests of back strength and lifting capacity in these two postures provide useful information to consider in determining the physiological and psychophysical stresses imposed by these work postures.

OP 159–86. Longwall Dust Control: An Overview of Progress in Recent Years, by Robert A. Jankowski, Fred N. Kissell, and J. Harrison Daniel. Min. Eng., v. 38, No. 10, Oct. 1986, pp. 953–958. This paper reviews the progress of dust control in longwall coal mining in the United States, highlighting the development of the shearer clearer, drum spray water supply systems, and improved cutting sequence designs. Other control methods such as ventilation strategies, the proportioning of water to the drums, and the remote control of the shearer from less contaminated locations are also discussed.

OP 160–86. The Vapor-Liquid Equilibria of the Aluminum Chloride-Titanium Tetrachloride System, by H. C. Ko and A. Landsberg. Metall. Trans. B, v. 17B, Sept. 1986, pp. 609–610. As part of an overall investigation of the possibility of using domestic clay to produce aluminum via an energy saving chloride process, the Bureau of Mines has determined vapor-liquid equilibria for the system aluminum chloride-titanium tetrachloride. The system was studied over the entire composition range and at temperatures of 187° to 217° C in sealed vessels such that the total pressures were not known. Results indicate two azeotropes of approximately 20 and 95 wt pct aluminum chloride. These findings suggest difficulties in distillation separation of these two products of clay chlorination.

OP 161–86. Safer and More Productive Mining With a Computer-Controlled, Water-Jet-Assisted Longwall Shearer, by Wilhelm J. Kogelmann and Edward D. Thimons. Paper in Proceedings of the Second International Conference on Innovative Mining Systems, University Park, PA, Oct. 27–29, 1986, ed. by Lee Saperstein. Penn State Univ., PA, 1986, pp. 56–68. This paper describes the basics of water-jet-assisted cutting, design features of the shearer and the testing of its components such as high pressure water pumps, phased rotary water seals, bit-force-actuated water valves, and jet nozzles. Also, the water-jetting system and its layout in the longwall installation and the underground cutting trial is discussed in detail.

OP 162–86. Soviet Union, by Richard M. Levine. Sec. in Mining Annual Review 1986, pp. 455–463. This article presents data based on sources published in the U.S.S.R. concerning the geologic, technologic, and economic influences on the minerals industry in that country. A commodities review is also included.

OP 163–86. The Development of a Water-Jet-Assisted Shearer Loader, by K. Neinhaus, H. Weigelt, and E. D. Thimons. Paper 8 in the Proceedings of the 8th International Symposium on Jet Cutting Technology, Durham, England, Sept. 9–11, 1986. BHRA, Cranfield, Bedford, England, 1986, pp. 79–92. This paper describes the application of water-jet-assisted cutting on the shearer loader and some of the potential advantages to be achieved: improved cutting, little wear, reduction of the dust make, elimination of sparks, and a coarser material obtained due to a deeper cut.

OP 164–86. Bibliography on In Situ Mining of Metals, by Joseph M. Pugliese and William C. Larson. In Situ, v. 10, No. 3, Sept. 1986, pp. 277–311. As part of the Bureau of Mines in situ mining research program, the Twin Cities Research Center compiled a comprehensive bibliography for in situ mining of metals. The listing reported here emphasizes publications only (no patents) on in situ mining of metals published in 1978 and later. Three previous Bureau publications (Bureau of Mines Information Circulars 8777, 8961, and 8969) include extensive bibliographies of pre-1978 in situ mining references. In this recent publication listing, each reference has been coded by topical acronyms shown under each reference. These acronyms, which are explained, provide an idea of what the reference covers and therefore represent an abbreviated subject summary.

OP 165–86. The Ambient Noise Floor in an Earcup of a Hearing Protector Worn by a Human Subject, by Gerald W. Redmond and J. Alton Burks. Paper in Proceedings of the International Conference on the Health of Miners, Pittsburgh, PA, June 2–7, 1985, ed. by Robert W. Wheeler. Am. Conf. of Gov. Ind. Hyg., Cincinnati, OH, v. 14, 1986, pp. 557–563. Hearing protective devices (HPD's) are necessary to control the noise exposure of miners when noise levels are in violation of Federal regulations and engineering or administrative controls cannot be implemented. However, standard laboratory performance measurements appear to overestimate the amount of protection a working miner may receive from HPD's. To more effectively evaluate hearing protector performance, the Bureau of Mines is investigating the basic parameters that influence the noise-attenuating properties of HPD's. Those parameters are being identified, and the degree to which they can be controlled under experimental conditions in the laboratory and field is being evaluated. With reasonable control over the stimulus and experimental parameters, it was possible to use a physical measurement procedure to predict the standard psychophysical method of evaluation in the laboratory. In attempting to adapt the method for use in the field, a high ambient noise level under the muff was observed. An experiment was designed to confirm and quantify the ambient noise level under an earmuff worn by a human subject. Preliminary analyses of the data tend to attribute the presence of the noise floor to human respiration and pulse. A discussion of the methods, results, and implications as to the effect of the noise floor on the physical measurement procedure will be presented.

OP 166–86. Whole Body Vibration Exposures of Coal Mining Machine Operators, by Gerald W. Redmond and P. J. Remington. Paper in the Proceedings of the International Conference on the Health of Miners, Pittsburgh, PA, June 2–7, 1985, ed. by Robert W. Wheeler. Am. Conf. of Gov. Ind. Hyg., Cincinnati, OH, v. 14, 1986, pp. 475–486. Field measurements utilizing a seat pad accelerometer were made on 61 surface coal mining machines and 25 underground coal mining machines in order to quantify the vibration levels experienced by the operators. Those data were combined with information on the statistics of the operating times of those machines in order to compare the operator's vibration exposure to the criteria in ISO 2631, A Guide for the Evaluation of Human Exposure to Whole Body Vibration. The comparison showed that about half of all surface coal mining machine operators can be expected to be exposed to vibration exceeding the fatigue decreased proficiency criterion, whereas only 15% would be expected to experience vibration exceeding the exposure limit. The comparison also indicated that about 30% to 40% of all underground coal mining machine operators can be expected to be exposed to vibration exceeding the fatigue decreased proficiency criterion and 10% to 15% would be expected to experience vibration exceeding the exposure limit. The primary sources of the exposure included scrapers, bulldozers, and loaders aboveground, and shuttle cars and possibly scoop trams underground. Detailed exposure statistics are presented and the implications of the results are discussed.

OP 167–86. A Mathematical Model To Predict the Potential Impact of Noise Control Measure on Reducing Miner Overexposures, by Robert W. Stephan, Gerald W. Redmond, and Roy C. Bartholomae. Paper in Proceedings of the International Conference on the Health of Miners, Pittsburgh, PA, June 2–7, 1985, ed. by Robert W. Wheeler. Am. Conf. of Gov. Ind. Hyg., Cincinnati, OH, v. 14, 1986, pp.

631–642. A statistical model is used to predict the number of miners overexposed to noise. A noise exposure probability is calculated for specific operator categories using information on mine worker population, exposure time, measured noise level of an associated piece of mining equipment, and the equipment duty cycle. In combination with information on equipment populations, the model can be used to rank-order the sources of miner overexposures. Also, by comparing noise levels of treated and untreated equipment, the model can be used to estimate the reduction in the number of overexposed miners and evaluate the impact of the control method. The prediction method has been computerized to facilitate the evaluation and comparison of various noise control treatments. The presentation includes a description of the prediction method and examples of its applications.

OP 168–86. Water-Jet-Assist for Rock Cutting, by Edward D. Thimons, Bradley V. Johnson, and Fred N. Kissell. Eng. Min. J., v. 187, No. 8, Aug. 1986, pp. 40–42. This paper describes recent research by the Bureau of Mines demonstrating that water-jet-assisted mechanical cutting can be useful under typical mining conditions.

OP 169–86. Thermal Analysis of Ion-Exchanged Montmorillonite, by S. W. Webb, D. A. Stanley, and B. J. Scheiner. Part. Sci. and Technol., v. 4, No. 4, Oct. 1986, pp. 131–142. As part of its program in mineral waste management, the Bureau of Mines has investigated the effect of ion exchange on the dewatering potential of clay minerals. Clays of the smectite group possess exchangeable cations to compensate for the overall net negative charge of the clay lattice. The ratio of the valence of the exchange cation to its ionic radius, referred to as the ionic potential, is indicative of the electrostatic influence that a given cation can exert on adjacent molecules. Differential scanning calorimetry and thermogravimetric analyses were performed on eight ion-exchanged montmorillonites (Li^+, Na^+, K^+, NH_4^+, Ca^{2+}, Ba^{2+}, Mg^{2+}, and Sr^{2+}). Results of these analyses indicate that the energy required to dehydrate the ion-exchanged montmorillonites and the associated dehydration water loss are directly related to the ionic potential of the exchange cation. Furthermore, the ordering influence of the exchange ion is responsible for different hydration states within the interlayer water.

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NEW PUBLICATIONS OF THE BUREAU OF MINES

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INFORMATION CIRCULARS

IC 9090. Primary Silver Availability—Market Economy Countries. A Minerals Availability Appraisal, by E. H. Boyle, Jr., G. R. Peterson, and P. R. Thomas. 1986. 36 pp. 14 figs. The Bureau of Mines has evaluated the potential availability of silver from 436 mines and deposits in 41 market economy countries (MEC's) comprising 5 major economic categories of deposits: predominantly silver deposits and predominantly zinc, lead, copper, and gold deposits. This study evaluated the long-term cost and availability of primary silver production from 53 producing and 13 nonproducing predominantly silver properties in 11 MEC's and estimated the total recoverable silver from 370 properties as a coproduct or byproduct of zinc, lead, copper, or gold production. This study resulted in estimates of a demonstrated resource of 5.99 billion tr oz of recoverable silver as of January 1984. Of this total, 23.5 pct is in the 66 mines and deposits classified as predominantly silver properties. The largest quantity of recoverable silver, 43.9 pct, lies in the 121 properties classified as predominantly zinc, with 26.5 pct in 120 properties classified as predominantly copper, 4.1 pct in 21 predominantly lead properties, and 2.0 pct in 108 predominantly gold properties. At current silver prices, the economics of silver production favor silver that is a byproduct or coproduct of zinc, lead, copper, or gold, and much of the silver production in the United States from the predominantly silver mines is at an economic disadvantage in comparison with silver production in other countries. GPO Stock No. 024–004–02171–3. $2.25.

IC 9101. Domestic Consumption Trends, 1972–82, and Forecasts to 1993 for 12 Major Metals, by Staff, Bureau of Mines, U.S. Department of the Interior, and Basic Industries Sector, U.S. Department of Commerce. 1986. 34 pp. 17 figs. Consumption and intensity of use trends for 12 metals, by industrial end use, were estimated for 1972 through 1982 by the Bureau of Mines and U.S. Department of Commerce. The trends were then forecast through 1993 using standard statistical methods. The intensity of use measures selected is the quantity of metal consumed per constant dollar output of a specific industrial sector. The metals studied were aluminum, chromium, cobalt, copper, lead, manganese, nickel, the platinum-group metals, tin, titanium, tungsten, and zinc. Average annual growth rates for the following 4 of the 12 metals increased from 1972 to 1982 as follows: aluminum, 1.00%; platinum-group metals (consisting of platinum, palladium, and iridium), 8.83%; titanium, 7.82%; and tungsten, 6.09%. Consumption for the remaining eight metals decreased at average annual rates ranging from 0.58% (copper) to 5.37% (manganese). GPO Stock No. 024–004–02170–5. $2.

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REPORTS OF INVESTIGATIONS

RI 9040. Direct Measurement of Longwall Strata Behavior: A Case Study, by Jeffrey M. Listak, John L. Hill III, and Joseph C. Zelanko. 1986. 19 pp. 19 figs. The Bureau of Mines has conducted a rock mechanics study to monitor deformation of near-seam strata above a longwall panel in the Pittsburgh Coalbed. The primary goal was to determine the height of caving immediately behind advancing longwall face supports. This study, although site specific, provides information on the caving mechanism associated with longwall extractions so that strata behavior and its interaction with longwall face supports can be better understood. Two holes were drilled, approximately 550 ft apart along the centerline of a longwall panel, from the surface to the coalbed approximately 650 ft below. Various downhole geotechnical instruments were used to monitor strata deformation. In addition, surface elevation surveys were conducted to differentiate between surface and subsurface activity. This report discusses the caving characteristics of the strata as the longwall panel approached and passed beneath the boreholes. Physical property data are also presented to demonstrate the relationship between caving behavior and local geology. Data show that immediate caving of strata above the longwall face occurred at a height less than 23.5 ft and that strata behavior above longwall extractions is highly dependent upon lithology, with major disturbances occurring at weak lithologic zones.

RI 9042. Calcium Sulfide Precipitation of Mercury From Gold-Silver Cyanide-Leach Slurries, by W. W. Simpson, W. L. Staker, and R. G. Sandberg. 1986. 8 pp. 3 figs. During cyanidation of mercury-bearing gold-silver ores, significant amounts of mercury are extracted. The presence of mercury decreases gold loading and increases mercury stripping time on activated carbon, complicates fire refining of the gold cathodes, and creates a potential health hazard. Addition of calcium sulfide (CaS) to the cyanide leach slurry precipitates the solubilized mercury but also some silver. The Bureau of Mines investigated silver loss during CaS precipitation of mercury. Addition of 0.1 lb CaS per short ton ore to a mercury-bearing gold-silver ore precipitated both mercury and silver. However, if copper was added with CaS, or if the ore contained copper,

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much of the silver loss was prevented. Addition of 235 ppm Cu with 0.1 lb/st CaS, prior to carbon-in-pulp adsorption, resulted in 89- to 97-pct, 80- to 91-pct, and 0-pct adsorption of the solubilized gold, silver, and mercury, respectively, on the activated carbon.

RI 9043. Electrochemical Determination of Thermodynamic Properties of $NiCr_2O_4$ and $CoCr_2O_4$, by Seth C. Schaefer. 1986. 11 pp. 7 figs. This report describes a Bureau of Mines investigation into the standard Gibbs energies of formation ΔG_f°, for $NiCr_2O_4$ (nickel chromite) and $CoCr_2O_4$ (cobalt chromite). High temperature galvanic cells employing stabilized ZrO_2 (zirconia) as the solid electrolyte were used to measure the open-circuit potentials for the cell reactions, and equilibrium oxygen pressures for the $Ni\text{-}Cr_2O_3\text{-}NiCr_2O_4\text{-}O_2$ system were determined from the electromotive force (emf) measurements.

RI 9044. Evaluation of Bearing Plates Installed on Full-Column Resin-Grouted Bolts, by Stephen C. Tadolini and Bryan F. Ulrich. 1986. 12 pp. 13 figs. The Bureau of Mines conducted field investigations in two underground mines to determine the actual loads to which bearing plates were subjected when installed in conjunction with full-column resin-grouted bolts and the roof movements generated by the applied loads. Measured loads indicate that the bearing plate is an integral part of the support system. Vertical displacement gauges installed to monitor roof displacements in the test sites show that the highest degrees of loading occur in conjunction with the largest amounts of movement.

RI 9045. Wood Crib Fires in a Ventilated Tunnel, by Margaret R. Egan and Charles D. Litton. 1986. 18 pp. 10 figs. This Bureau of Mines report presents results from experimental studies on wood crib fires in an intermediate-scale fire tunnel. Gas concentrations, smoke particle characteristics, heat release rates, and ventilation rates were determined. These measurements form a data base for wood, which can be used with previous analyses for coal and future studies of other mine combustibles, to comprehend the potential hazards of these materials in underground mine fires. A knowledge of the combustion products emitted from these materials will benefit fire detection and control. Results show the changes in burning rate and heat release rate produced by different crib configurations and ventilation rates. Also included are the effects that the burning rate has on smoke characteristics and gas production.

RI 9046. Longwall Shearer Performance Using Water-Jet-Assisted Cutting, by P. D. Kovscek, C. D. Taylor, H. Handewith, and E. D. Thimons. 1986. 15 pp. 12 figs. The Bureau of Mines equipped a longwall shearer with a water-jet-assisted mechanical cutting system to determine the effect of the high-pressure sprays on machine performance, airborne dust levels generated, and size of particles formed. Testing was conducted on a simulated coal block (coalcrete) while cutting at a water pressure of 190 psi and at water-jet-assisted pressures ranging from 1,000 to 6,000 psi. The shearer motor energy used by the shearer while cutting coalcrete was determined for each cutting condition. Results indicate that the motor energy required by the shearer for each ton of material cut did not vary significantly as the water pressure was increased. Results of dust measurements recorded near the cutting drum indicate that at water pressures above 3,000 psi, dust reductions up to 85 pct were achieved compared with cutting with conventional sprays. Analysis of the particle size distribution during cutting showed that increasing the water pressure resulted in increased median particle size. In light of these results, various mechanisms for water-jet-assisted cutting are discussed.

RI 9047. Effect of Alloying Elements on Oxidation of Low-Chromium Alloys, by Je M. Oh. 1986. 12 pp. 18 figs. The Bureau of Mines is conducting research to determine the high-temperature oxidation resistance of substitute stainless steels (SS) containing two less strategic elements, Al and Si, instead of Cr. Chromium is considered to be a critical and strategic metal. Although the Cr content was reduced to 8 wt pct, the alloys showed better oxidation resistance than did 304 SS containing 18 wt pct Cr. Specifically, the alloys that contained Fe-8Cr-16Ni with combinations of Al and Si showed excellent oxidation resistance even at temperatures up to 1,000° C. In this study, the effects of the alloying elements on oxidation kinetics and morphology of oxides were investigated using a Cahn Rg electrobalance, scanning electron microscopy, an energy-dispersive X-ray analyzer, X-ray diffraction, and an electron microprobe. Aluminum and silicon additions in combination were more effective in providing oxidation resistance than either element was alone.

RI 9048. A Statistical Determination of Spark Ignition Safety Factors in Methane, Propane, and Ethylene Mixtures in Air, by James C. Cawley. 1986. 15 pp. 13 figs. The Bureau of Mines conducted an investigation to statistically determine the mean current or voltage for resistive, inductive, and capacitive circuits that would cause spark ignitions in 8.3% methane-air, 5.3% propane-air, and 7.8% ethylene-air mixtures. Each mean ignition current or voltage was determined on the basis of 100 trials. Each trial consisted of 400 revolutions, 200 in each polarity, at 80 rpm of the standard breakflash apparatus. In general, spark ignition curves published in UL 913 for resistive and inductive circuits represent approximately the mean current values determined in this study, while published capacitive circuit values in methane are considerably less than the mean voltage values from this study, especially for a capacitance of less than 100 μF. For resistive and inductive circuits, spark ignitions were obtained at currents considerably below those in the published curves, but this study was not optimized to find minimum ignition values. This report defines "safety factor" as applied to intrinsic safety testing as the energy ratio of the mean values of ignition current or voltage for two test gases. The safety factors presented in this report are not constant with voltage or current and, therefore, are not recommended for use.

RI 9050. A Method for Locating Abandoned Mines, by R. G. Burdick, L. E. Snyder, and W. F. Kimbrough. 1986. 27 pp. 15 figs. The problems presented by old mine workings affect both present-day mining and land development. An automated method of locating these old mines from the surface using electrical resistivity techniques was developed earlier under a Bureau of Mines contract. Subsequent Bureau research has refined the techniques and expanded the area of study to a variety of geologic provinces. During this research, six mining areas in the United States were investigated with the Bureau's automated resistivity method. This report describes the mining areas involved and the results of the resistivity investigations, which showed a high rate of success in detecting old mines. It also describes the field measurement techniques and data analysis procedures.

RI 9051. Self-Contained Self-Rescuer Field Evaluation: First-Year Results of 5-Year Study, by N. Kyriazi, J. G. Kovac, J. Shubilla, W. Duerr, and J. Kravitz. 1986. 12 pp. 10 figs. A joint effort by the Bureau of Mines and the Mine Safety and Health Administration, U.S. Department of Labor, was undertaken to determine how well self-contained self-rescuers (SCSR's) deployed in accordance with Federal Regulations (30 CFR 75.1714), held up in the underground environment. This report presents findings regarding laboratory-tested breathing apparatus from the first year of a 5-yr program as well as other related findings. The SCSR's were tested on human subjects and on a breathing and metabolic simulator. These results indicate that the apparatus, if well-treated, perform as expected except for manufacturing defects or quality control problems, which are identified. However, when the apparatus are carried in and out of the mine every day and stored at the working section, they may suffer abuse that can be extreme. Physical signs of abuse, unless extremely obvious, frequently are not detected by the miners or the mine operators; this poses a danger to a potential user in case of emergency. Recommendations include improved training in inspection procedures.

RI 9052. Steam-Induced Volatilization of Silica From Refractories, by L. Y. Sadler III and E. G. Davis. 1986. 10 pp. 7 figs. The Bureau of Mines conducted a study to determine the loss in weight of silica (SiO_2) volatilization from low-alumina

(Al_2O_3) refractories used as hot face liner materials in such process equipment as coal gasifiers, synthesis gas transfer lines, and ammonia plant secondary reformers. Small specimens of 80- and 40-pct-Al_2O_3 brick and 95-pct-SiO_2 brick were exposed to steam in high-pressure furnaces at pressures of up to 1,000 psig and temperatures up to 1,400° C for periods ranging up to 120 h. Weight losses from the 40-pct-Al_2O_3 brick after 40 h of exposure were highest, 2.75 pct at 1,400° C and 1,000 psig. The rate of weight loss had dropped to near zero after 80 h of exposure at all temperatures. No relationship between total silica content of the specimen and weight loss could be established nor did scanning electron microscopic examination of the specimens before and after exposure identify specific regions (e.g., surface) suffering a disproportionate share of the silica loss. It was concluded that minor silica volatilization is likely to occur, if at all, at temperatures of less than 1,000° C and pressures below 1,000 psig, and that low-alumina refractories should be used as dry-ash coal gasifier hot face linings.

RI 9053. Particle Size Distribution of Quartz and Other Respirable Dust Particles Collected at Metal Mines, Nonmetal Mines, and Processing Plants, by Charles W. Huggins and Gail T. Meyers. 1986. 8 pp. The primary objective of this Bureau of Mines research was to measure the size distribution of respirable quartz collected at metal mines, nonmetal mines, and processing plants to select the best reference standard for use in quantifying quartz in mine and plant dust samples. The secondary objective was to size all the nonquartz particles collected at the same sites. Particle size measurements were made on 29 samples using a scanning electron microscope in the backscatter mode of operation, interfaced with an image analysis system. The Mine Safety and Health Administration, Denver, CO, provided the 29 samples, which were collected at mines and processing plants in 19 States. The accumulated particle size measurements indicate that NBS 1878, minus 5-μm Min-U-Sil, and minus 5-μm Supersil would be preferred over Silver Bond B as reference standards for most quantitative determinations by X-ray diffraction and infrared spectrometry. The respirable dust samples collected at sand plants, however, would be better served by a new reference standard having a quartz particle size distribution of approximately 2.2 μm, as none of the four existing reference standards matched closely with them. Commercially available NBS 1878 and minus 5-μm Min-U-Sil could be used as reference standards for 28 of the 29 samples studied in this investigation.

RI 9054. Firing Delay Characteristics of Instantaneous and Seismic Detonators, by T. S. Bajpayee, Richard J. Mainiero, and J. Edmund Hay. 1986. 10 pp. 4 figs. This report describes an evaluation by the Bureau of Mines of the firing delay and interval of commercially available instantaneous and seismic detonators considered for use with nonincendive sheathed explosive rock-breaker charges. Detonators manufactured by three domestic companies were evaluated. Time measurements were based on the principle of detecting ionization at the detonation front. High-resolution digital oscilloscopes and twisted-pair ionization probes were integral parts of the experimental setup. Firing delays and firing intervals were measured using 3 different test procedures: (1) 3 detonators in series with a 100-ft-long 16-gauge firing line fired by a 20-shot permissible blasting machine, (2) 2 detonators in series fired by a 20-shot blasting machine through a total circuit resistance of 25 ohms, and (3) 2 detonators in series fired by a 20-shot permissible blasting machine through a total circuit resistance of 150 ohms.

RI 9056. Strata Interactions in Multiple-Seam Mining—Two Case Studies in Pennsylvania, by Gregory J. Chekan, Rudy J. Matetic, and James A. Galek. 1986. 17 pp. 22 figs. The Bureau of Mines, in an effort to improve planning and development in coal mining, is investigating strata interactions associated with mining of multiple coalbeds. Two common interactions that occur between adjacent coalbeds are subsidence and pillar load transfer. The study described involves underground observations and measurements conducted at two Pennsylvania mines, each affected by one of these interactions. At the mine affected by subsidence, measurements show that undermining had little effect on upper mine pillar stability, but had a more severe effect on the development and maintenance of entries. Roof-to-floor measurements recorded over four times more convergence in entries developed over gob as compared with entries developed over support pillars in the lower mine. At the mine affected by pillar load transfer, initial in situ measurements have shown the existence of a pressure arch in the lower workings. Prior research has shown that arch interaction between two adjacent openings can create stress concentrations in the innerburden. Underground measurements and results obtained from both mine sites correlate with theoretical and photoelastic multiple-seam models, and eventually these field data will serve to refine model accuracy. Further study of multiple-seam interaction mechanisms will lead to improved mine planning, increased resource conservation, and a safer working environment.

RI 9057. Thickening Fine Coal Refuse Slurry for Rapid Dewatering and Enhanced Safety, by Bill M. Stewart, Ronald R. Backer, and Richard A. Busch. 1986. 12 pp. 5 figs. To decrease the potential for fine coal waste slurry impoundment failures, the Bureau of Mines investigated a new disposal technique. The fine coal waste slurry is rapidly thickened (i.e., dewatered) and deposited on a slightly sloping surface. To accomplish rapid dewatering, a chemical flocculation system using polymers was developed to treat the fine coal waste slurry stream. The fine solids formed flocs, settled from suspension, and rapidly released excess water. During the last 5 days of the field test, slurry flowing at rates from 492 to 675 gal/min with a specific gravity range of 1.15 to 1.33 was successfully treated and dewatered. During this period, untreated slurry had an average moisture content of 227.4 pct (30.7 wt pct solids). The effectiveness of the dewatering system was determined by monitoring the moisture content of the deposited waste with respect to time. Sixty-five hours after ending the field test the average moisture content was 54.9 pct (64.5 wt pct solids); 68 days after the field test the average moisture content was 28.8 pct (78.0 wt pct solids).

RI 9058. Oxidative Thermal Degradation of PVC-Derived, Fiberglass, Cotton, and Jute Brattices, and Other Mine Minerals. A Comparison of Toxic Gas and Liquid Concentrations and Smoke-Particle Characterization, by Maria I. DeRosa and Charles D. Litton. 1986. 13 pp. 10 figs. The Bureau of Mines performed experiments to determine concentrations of toxic gases and liquids, and smoke-particle diameters and diameter-concentrations evolved during degradation of PVC-derived brattice with and without nylon-woven fabrics, fiberglass, cotton, and jute brattices, and other mine materials. The samples were exposed in a 20-L chamber at temperatures of 150° to 450° C, with a chamber airflow of 10 L/min; 27.3 cm^3/s of which was directed into a submicrometer-particle detector-analyzer. During the degradation of PVC-derived brattice, large concentrations of hydrogen chloride (TLV, 5 ppm; STEL, 100 ppm) evolved at a temperature as low as 200° C. The minimum toxic load of 3.1 mg or 40 ppm in 50 L of dilution air, with 0.1-g weight loss, may be reached at a mine face with 314,000 L of dilution air, at the 5th min, during which less than 1 kg of brattice undergoes combustion. Fiberglass, cotton, and jute brattices, pine wood dust, and coal dust showed small concentrations of carbon monoxide evolving during early stages of combustion. Hydrogen cyanide gas evolved from the PVC-derived, nylon-reinforced brattice; at a later stage of combustion, large concentrations of carbon monoxide and dense smoke evolved from all PVC-derived brattices. Experiments to characterize smoke particles showed that marked differences exist in particle diameter-concentrations among the materials.

RI 9059. Thermal Gravimetric Analysis of Pyrite Oxidation at Low Temperature, by J. E. Pahlman and G. W. Reimers. 1986. 12 pp. 8 figs. Spontaneous oxidation and combustion of sulfides and resultant fires are serious problems in underground mines. The Bureau of Mines has conducted fundamental thermal gravimetric analysis (TGA) research to determine the mechanisms and factors governing the rate of low-temperature pyrite oxidation, and to identify possible inhibitors to spontaneous oxidation and combustion. The mechanism of low-temperature pyrite oxidation was found to be topochemical, meaning that the oxidation process is controlled

by the chemical reaction at the interface between pyrite (FeS_2) and iron sulfate ($FeSO_4$). An activation energy of 8.9 kcal/mol FeS_2 was obtained for oxidation of minus 500-mesh pyrite in an atmosphere of 60 vol pct water vapor and 40 vol pct O_2. Water-vapor content of the atmosphere was found to be the critical factor in the rate of spontaneous oxidation of pyrite, with a water-vapor content greater than 20 vol pct needed for accelerated oxidation. An atmosphere of pure oxygen resulted in negligible oxidation. The rate of pyrite oxidation is also greatly affected by the particle size of pyrite. Pyrite-oxidation rate increased drastically for particles less than 40 μm. Room-temperature pyrophoric behavior was observed for freshly ground unoxidized pyrite (55 pct minus 5 μm) upon exposure to air. Addition of water-adsorbing materials such as activated alumina (Al_2O_3) decreased the rate of pyrite oxidation.

INFORMATION CIRCULARS

IC 9093. Development of a Protective Operator Compartment for a Thin-Seam Mobile Bridge Carrier, by August J. Kwitowski and Robert J. Gunderman. 1986. 27 pp. 61 figs. This Bureau of Mines report summarizes the development of a protective operator compartment for a new generation thin-seam mobile bridge carrier. The developed compartment is commercially available and is currently employed on approximately 15 bridge carriers used in the mining industry. The design of the compartment, which employed human factors engineering and small- and full-scale mockup models, is fully described. Details of the compartment's fabrication, evaluation, and demonstration in a commercial low-seam coal mine are also provided.

IC 9095. Safe Cleaning of State of Maine Filters Using EDTA-Type Chelating Agents, by John E. Pahlman and Daniel N. Tallman. 1986. 12 pp. 9 figs. An increasing number of gold and silver mining operations are employing cyanide solutions to effectively dissolve silver and gold from finely disseminated ores. Many of these operations use small, packaged processing systems like the State of Maine filter system, which employs zinc precipitation of gold and silver. Solution-clarifying filters in these systems become blinded with calcium carbonate ($CaCO_3$) scale and require frequent (every 2 to 10 days) dismantling of the filter units for acid cleaning. This is a hazardous operation as it is not compatible with the alkaline cyanide leach solutions and may result in the evolution of toxic hydrogen cyanide (HCN) gas during cleaning and during any accidental acid spill. The Bureau of Mines has investigated an alternative, nonacidic method of cleaning blinded State of Maine filters that employs ethylene-diamine-tetraacetic-acid (EDTA) type chelating agents to dissolve the scale. In situ cleaning of a 150-st/d State of Maine filter with EDTA-type chelating agents was successfully demonstrated. Greater than 90 pct of the $CaCO_3$ scale was removed in about 10 min with circulation of 31 L of 2.5-pct-EDTA solution through the filter unit. The EDTA cleaning method not only eliminates the cyanide hazard in filter cleaning but is advantageous from the standpoint of operating costs and productivity.

IC 9097. Bureau of Mines Research Into Reducing Materials-Handling Injuries, by Richard L. Unger and Thomas G. Bobick. 1986. 22 pp. 14 figs. The Bureau of Mines entered into a cooperative agreement with an eastern Kentucky coal mining company to comprehensively redesign the flow of equipment and supplies throughout its underground mines. Items were tracked from delivery to the warehouse and from surface storage areas to their final usage locations underground. Three underground mines were visited, and a great variety of tasks were videotaped for subsequent laboratory analysis. Of particular interest were tasks that required manual handling of the supplies or equipment components. Activities such as handling daily supplies (concrete blocks, rock dust, and crossbeams) and handling or lifting the continuous miner power cable were determined to be the most hazardous. Recommendations to the company included redesigned surface storage areas to facilitate the use of forklift vehicles to load the underground supply cars. Designs were also developed for different mechanical-assist devices to help in unloading the supply cars underground and to handle equipment maintenance tasks underground. Additionally, the videotapes of the underground manual handling tasks became the basis for simulating those activities in controlled laboratory conditions. This testing will contribute to developing guidelines for proper lifting techniques for low-seam coal mines.

IC 9099. Surface Subsidence Over Longwall Panels in the Western United States—Monitoring Program and Final Results at the Price River Coal Co. No. 3 Mine, Utah, by Alan J. Fejes. 1986. 21 pp. 20 figs. As part of its mine subsidence research program, the Bureau of Mines and the American Electric Power Co. cooperated on a study, conducted at the Price River Coal Co. No. 3 Mine, directed toward developing the capability to estimate the surface subsidence resulting from longwall mining in a geologic, topographic, and mining environment common to coalfields in the Western United States. Subsidence was monitored at the No. 3 Mine over two adjacent longwall panels. The subsidence study area was reduced when the two planned panels were reduced in length because of equipment failure and a mine fire. Subsidence was measured for 21 months. Subsidence continued for 6 months after mining had been completed. A maximum of 2.2 ft of subsidence occurred over the two longwall panels mined at an overburden depth ranging from 800 to 1,500 ft.

IC 9102. Lithium Availability—Market Economy Countries. A Minerals Availability Appraisal, by D. I. Bleiwas and J. S. Coffman. 1986. 23 pp. 7 figs. The Bureau of Mines determined the costs associated with lithium production (in various products) from demonstrated resources in seven market economy countries (MEC's). This analysis evaluated the relative economic and resource position of 16 mines or deposits, including 6 producers and 1 (Bernic Lake) operating at pilot scale. The demonstrated resource of recoverable lithium within the deposits studied is approximately 2.2 million metric tons. Virtually all known MEC resources and production were covered, including resources in Chile (59 pct of the total), the United States (13 pct), Australia (11 pct), Canada (10 pct), and Bolivia, Zaire, and Zimbabwe (combined 7 pct). In addition, the large potential of lithium-enriched brines is assessed, especially those in the Atacama Basin, Chile, where production began in 1984. The lithium resource consists of lithium in spodumene, brines, and to a small extent lepidolite and petalite. Most MEC lithium trade originates from the United States, though development of brine deposits in Chile, and potential development in Bolivia, could threaten the U.S. position. Economic analysis indicated that all lithium being recovered from producing properties could be produced at less than the published market price, and that MEC resources from these properties are adequate to supply any foreseeable demand.

IC 9105. A Columbium-Bearing Regolith on Upper Idaho Gulch, Near Tofty, AK, by J. Dean Warner, C. L. Mardock, and D. C. Dahlin. 1986. 29 pp. 20 figs. In 1984, as part of a project to evaluate Alaskan occurrences of certain critical and strategic minerals, the Bureau of Mines investigated a columbium-bearing regolith on upper Idaho Gulch, near Tofty, AK. The regolith is derived from weathering of a dolomitic marble and consists mostly of iron oxide minerals with accessory apatite, zircon, xenotime, rutile, monazite, and the columbium minerals aeschynite, columbite, and ilmenorutile. Two regolith lenses contain 340,000 lb of columbium resources at an average grade of 0.07 pct. Calculated composite concentrates from two regolith samples (approximately 200 lb each) contained 53 and 57 pct of the columbium at grades of 0.97 and 0.26 pct, respectively. In each case the grade could be improved to 1.1 pct Cb with a sacrifice of 9-pct recovery. The regolith's mineralogy, trace-element geochemistry, and similarity to descriptions of other columbium-enriched regoliths suggest that the underlying marble may be a carbonatite. The lack of associated alkalic igneous rocks and the stratiform nature of the regolith, however, may be interpreted as evidence for sedimentary origin of the marble. The marble and regolith are a lode source for some of the minerals in the Idaho Gulch placer deposit.

IC 9108. Water-Jet-Assisted Roadheaders, by Robert J. Timko, Bradley V. Johnson, and Edward D. Thimons. 1986. 11 pp. 13 figs. Water-jet-assisted cutting involves the use of a mechanical cutting bit in combination with a high-pressure water jet directed just in front of the bit tip. Such a jet can offer benefits in terms of improved cutting, reduced dust and fines, and improved bit wear. The Bureau of Mines, through a contract with the British National Coal Board, has researched the use of water-jet-assisted cutting on roadheaders. After several engineering design problems were overcome, this program led to the successful underground testing of these roadheaders. Today, more than 60 water-jet-assisted roadheaders are in operation around the world, and numerous others are on order. This paper details the evolution of these machines and the benefits to be gained by their use.

IC 9111. Availability of Rare-Earth, Yttrium, and Related Thorium Oxides—Market Economy Countries. A Minerals Availability Appraisal, by T. F. Anstett. 1986. 19 pp. 11 figs. The Bureau of Mines estimated the potential availability of rare-earth oxides (REO), including yttrium and thorium, which is also contained in the rare-earth bearing minerals monazite and bastnasite, from 38 properties in market economy countries (MEC's). Only nine of the properties evaluated produce or would produce REO as the primary product; the others contain REO as a byproduct, chiefly from mineral sands operations recovering rutile, ilmenite, and zircon. Nearly 77% (2,578,000 mt) of the total 3,355,000 mt of recoverable REO evaluated is from producing properties. It is estimated that 21% (705,000 mt) of this total is from properties that could not realize a positive rate of return at the January 1984 market prices for the recovered commodities. At production capacities assumed for this evaluation, the amount of REO potentially available from producers ranges from an estimated 46,500 mt in 1986, to a peak of 50,900 mt in 1992, to 49,900 mt by the year 2000. Total MEC production in 1984 was estimated at 40,700 mt. Assuming demand does not increase sharply, producing properties can continue to fulfill overall REO demand through at least the end of this century.

IC 9112. Magnesium Availability—Market Economy Countries. A Minerals Availability Appraisal, by D. R. Wilburn. 1986. 24 pp. 9 figs. The Bureau of Mines investigated the potential availability of magnesium from 45 properties in market economy countries (MEC's). The 38 significant deposits evaluated have demonstrated resources of approximately 29 billion short tons (st) magnesium-bearing material containing 416 million short tons (MMst) magnesium oxide (MgO). Using data it gathered, the Bureau determined the magnesium production potential for each property including a 15-pct rate of return on invested capital. Total and annual availability assessments for the next 30 yr were completed for magnesium (Mg) metal, dead-burned MgO, and caustic calcined MgO. At a January 1984 market price of $1.34/lb Mg metal, the properties evaluated could economically produce an estimated 13 MMst Mg metal. At a market price of $400/st nonmetal magnesium product, these properties could economically produce 109 MMst deadburned MgO and 43 MMst caustic MgO. These properties could produce approximately 301,000 st Mg metal, 3.0 MMst deadburned MgO, and 430,000 st caustic MgO annually at current full production levels and 1984 market prices until at least the year 2000. Total 1984 MEC production assessed in this study was 153,000 st Mg metal and 4.3 MMst nonmetallic MgO products.

IC 9114. Dust Controls To Improve Quality of Longwall Intake Air, by John A. Organiscak, Robert A. Jankowski, and Jonathan S. Kelly. 1986. 8 pp. 8 figs. The Bureau of Mines has recently completed a program to identify and evaluate various methods that address control of dust generated outby the longwall mining face. Dust generated by the stageloader-crusher, the panel belt, and the intake roadway can be long-term throughout the shift, contributing significantly to the dust exposure of all face workers. Dust control techniques were identified and tested at a number of longwall mining sections located in diverse geological conditions across the United States. Dust controls investigated include (1) methods that eliminate the sources of intake dust contamination—homotropal ventilation, (2) methods to limit the amount of respirable dust released into the intake airstream—improved water application and the use of curtains and enclosures, and (3) methods to clean the contaminated air prior to delivery to the mining face—scrubber systems. Usually they can be implemented at a low cost and can be very effective. This report describes each technique and its application and presents the resulting conclusions.

PREPRINTS FROM MINERALS YEARBOOK, 1985

These preprints are chapters from Minerals Yearbook, 1985. The complete yearbook will be available later. The preprints present data on production, consumption, exports, imports, and technological advances.

Cement, by Wilton Johnson. 26 pp. 1 fig.
Dimension Stone, by Harold A. Taylor, Jr. 11 pp.
Ferroalloys, by Raymond E. Brown. 26 pp.
Iron and Steel Scrap, by Franklin D. Cooper. 25 pp. 1 fig.
The Mineral Industry of Algeria, by Kevin Connor. 8 pp.
The Mineral Industry of Iran, by Michael D. Fenton. 10 pp.
The Mineral Industry of Jordan, by Michael D. Fenton. 7 pp.
The Mineral Industry of Kuwait, by Michael D. Fenton. 6 pp.
The Mineral Industry of Pakistan, by Charles L. Kimbell. 11 pp.
The Mineral Industry of Peru, by Doris M. Hyde. 12 pp.
The Mineral Industry of Poland, by John R. Craynon. 11 pp.
The Mineral Industry of Spain, by John R. Craynon and Roman V. Sondermayer. 16 pp.
The Mineral Industry of Switzerland, by John R. Craynon. 11 pp.
The Mineral Industry of Taiwan, by E. Chin. 11 pp.
The Mineral Industry of Tunisia, by Kevin Connor. 10 pp.
The Mineral Industry of the United Kingdom, by Richard H. Singleton. 23 pp.
The Mineral Industry of Islands of the Caribbean, by Doris M. Hyde. 21 pp.
The Mineral Industry of Other South Pacific Islands, by Travis Q. Lyday. 7 pp.
Silver, by Robert G. Reese, Jr. 20 pp.
Zinc, by James H. Jolly. 28 pp.

III. Open File Reports—NTIS

An open file report is an unpublished Bureau of Mines report that has been made available as reference material. Any open file report may be inspected during working hours at the locations indicated but may not be removed, except that the Natural Resources Library, U.S. Department of the Interior, Washington, DC 20240, can usually supply copies on interlibrary loan. For further information, contact the library, 202–343–5815.

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AD/MR	**Assistant Director—Mining Research, USBM, Washington, DC.**
AFOC/A	**Alaska Field Operations Center, USBM, Anchorage, AK.**
AFOC/F	**Alaska Field Operations Center, USBM, Fairbanks, AK.**
AFOC/J	**Alaska Field Operations Center, USBM, Juneau, AK.**
ALRC	**Albany Research Center, USBM, Albany, OR.**
AVRC	**Avondale Research Center, USBM, Avondale, MD.**
DOI	**U.S. Department of the Interior.**
DRC	**Denver Research Center, USBM, Denver, CO.**
IFOC	**Intermountain Field Operations Center, USBM, Denver, CO.**
LIB	**Natural Resources Library, DOI, Washington, DC.**
MSHA	**Mine Safety and Health Administration, Arlington, VA.**
NMH&SA	**National Mine Health and Safety Academy, Beckley, WV.**
OSM	**Office of Surface Mining Library, DOI, Washington, DC.**
PRC/B	**Pittsburgh Research Center (Bruceton), USBM, Pittsburgh, PA.**
RERC	**Reno Research Center, USBM, Reno, NV.**
RORC	**Rolla Research Center, USBM, Rolla, MO.**
SLRC	**Salt Lake City Research Center, USBM, Salt Lake City, UT.**
SRC	**Spokane Research Center, USBM, Spokane, WA.**
TCRC	**Twin Cities Research Center, USBM, Twin Cities, MN.**
TURC	**Tuscaloosa Research Center, USBM, Tuscaloosa, AL.**
USBM	**U.S. Bureau of Mines.**
WFOC	**Western Field Operations Center, USBM, Spokane, WA.**

OFR 92–86. Changes in Worldwide Demand for Metals, by Jack G. Faucett and Harry J. Chmelynski. Aug. 1986. 179 pp. 68 figs. Worldwide demand for metals has been analyzed to identify the important factors that explain differences in the level of demand among world countries. The per capita demand for steel, aluminum, copper, and total nonferrous metals has been investigated for 40 to 50 countries over a 22-year period. These countries have been further grouped into four world regions for purposes of making generalizations about the importance of these factors for countries in different stages of development and with dissimilar levels of per capita gross domestic product (GDP). Intercountry and intertemporal differences are explained largely by differences in per capita GDP and changes over time in per capita GDP, oil real prices, and to a lesser extent, metal real prices. The trend in world consumption is dramatically different in the last decade than the previous one. In 1962–73, per capita consumption increased in all areas and consumption intensity (consumption divided by GDP) increased in most areas. In 1973–84, per capita consumption fell in most areas and intensity fell dramatically, except in developing nations. Research was done under contract J0156030 by Jack Faucett Associates. Available for reference at AFOC/J, ALRC, AVRC, DRC, IFOC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, TURC, and WFOC. Order ONLY from NTIS: PB 87–119012; paper copy price code A09. $18.95.

OFR 95–86. Availability of Strategic and Critical Minerals: Role of the Republic of South Africa, by Staff, Minerals Availability Program. Oct. 1986. 111 pp. 21 figs. Possible consequences of continuing internal political unrest and the imposition of foreign sanctions raise concerns about the traditional reliability of the Republic of South Africa (South Africa) as a major world supplier of important minerals. A recent Bureau of Mines technical report (Open File Report 76-86) examined the impact of temporary peacetime disruption scenarios for six key materials (chromium, cobalt, gold, manganese, platinum-group metals, and vanadium) and mitigating options. Because of South Africa's dominant producer position for these minerals (except for cobalt), expansion of primary production capacity outside of South Africa is not a short-term mitigative option. However, prospects of a longer term disruption would likely spur investment in capacity expansion in alternative market economy country (MEC) supply sources. This report identifies the resources, production costs, and burdens that would be placed on alternative MEC producers of chromium, cobalt, gold, manganese, and platinum-group minerals if South Africa's production were subject to a long-term disruption. When long-term supplies from South African deposits are discounted, more than a few years reserves were found only for cobalt and manganese. Even for these two minerals, higher sustained prices would be required to increase manganese production capacity and to support means of cobalt transportation not through South Africa. Research was done by the U.S. Bureau of Mines. Available for reference at AD/MDA, AFOC/J, IFOC, LIB, and WFOC. Order ONLY from NTIS: PB 87–119038; paper copy price code A06. $18.95.

OFR 96–86. Flywheel-Powered Shuttle Car, by Donald Christofferson. Mar. 1986. 173 pp. 26 figs. This report documents the program conducted to demonstrate the application of a flywheel-powered propulsion system to underground mining shuttle cars. Such application can replace the present electrical trailing cable common to most shuttle cars and thereby eliminate those safety hazards, maintenance problems, and haulage route limitations inherent in the trailing cable. Described are the activities undertaken to specify and design a flywheel of optimum size, shape, and material; to identify the best concepts of input and output systems; and to achieve installation of the power package into a shuttle car. The resultant flywheel-powered shuttle car is an FMC Corp. Model 6L shuttle car, 6-ton capacity, 20-ton gross vehicle weight, powered by a flywheel system with 4.5-kilowatt-hour usable energy. The completed vehicle was delivered to the Bureau of Mines in Bruceton, PA, for testing and evaluation. Research was done under contract J0333911 by Engineered Systems & Development Corp. Available for reference at AD/MR, ALRC, AVRC, DRC, LIB, PRC/B, RERC, RORC, SLRC, SRC, TCRC, and TURC. Order ONLY from NTIS: PB 87–119079; paper copy price code A08. $18.95.

MINERAL LAND ASSESSMENT REPORTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Division of Mineral Land Assessment, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

MLA 66–86. Mineral Investigation of the Mount Wilson Wilderness Study Area (AZ–020–001A), Mohave County, Arizona, by George S. Ryan. 1986. 15 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MLA 67–86. Mineral Investigation of the Fish Springs Range Wilderness Study Area (UT–050–127), Juab County, Utah, by Stanley L. Korzeb. 1986. 11 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.

MINERAL INSTITUTES REPORTS

The mineral institutes program operates under Public Law 98–409 and under title III of Public Law 95–87. It is designed to improve the quality of mineral engineering research and education through support for research in mining, metallurgical processing, and related mineral sciences. The Bureau of Mines

supports this research through annual allotment grants, matched by non-Federal funds, to mineral institutes at 31 universities throughout the United States, and by research grants to these institutions to address specific mining and processing problem areas.

The following report describes research conducted under research grants. Individual copies may be available from the author of the paper at the university cited. Copies of this report are NOT available from the Bureau of Mines.

MIR 16–86. A Comparison of Empirical/Theoretical, Laboratory, and Field Techniques in Evaluating Unsaturated Properties of Mill Tailings, by Mark B. Larson. M.S. Thesis, NM Inst. Min. and Technol., Socorro, NM, Aug. 1984. 287 pp. 115 figs. This report compares some of the empirical-theoretical, laboratory, and field techniques available to evaluate saturated hydraulic conductivity, soil moisture characteristic curves, and relative hydraulic conductivity. This research was done under grant G1125132–3502 at the New Mexico Institute of Mining and Technology.

IV. Outside Publications

The following are articles by Bureau of Mines personnel in non-Bureau publications that came to our attention in 1986. In addition to Bureau authors, this section may contain some non-Bureau coauthors. Copies of these articles are NOT available from the Bureau of Mines.

OP 170–86. Heat Capacities of α-Cobalt Sulfate From 5.3 to 300.1 K, by Harry E. Bell and Richard P. Beyer. J. Chem. Eng. Data, v. 31, No. 4, Oct. 1986, pp. 381–383. As part of a U.S. Bureau of Mines effort to provide thermodynamic data on minerals and related inorganic compounds, the heat capacity of α-$CoSO_4$ was measured from 5.3 to 300.1 K by adiabatic calorimetry, thereby extending the range of existing measurements below 52 K. The heat capacity of α-$CoSO_4$ was measured previously from 52 to 296 K using an isothermal shield calorimeter.

OP 171–86. The Use of AC Impedence To Determine the Corrosion Rate of Electrogalvanized Steel, by Marion Datillo. Mater. Perform., v. 25, No. 11, Nov. 1986, pp. 18–22. This paper presents Bureau of Mines research into the corrosion rate of industrial electrogalvanized steel in deaerated molar ammonium sulfate by dc and ac electrochemical techniques as compared to solution analysis by atomic adsorption. An evaluation of the zinc coatings obtained in an industrial-scale test has shown that coatings obtained from a waste-derived electrolyte perform better than normal industrial coating. Impedance diagrams show that a slightly different frequency distribution is obtained for the two different coatings studied. The time dependence of the zinc corrosion rate can be monitored using impedance data over a frequency range of 0.1 to 11 Hz. Admittance plots provided the double-layer capacitance values, which indicate the presence or absence of surface corrosion products. The results show that electrochemical ac techniques can be applied to successfully determine the zinc corrosion rate of electrogalvanized steel in near-neutral media and that waste sources of zinc are viable for electrogalvanizing steel.

OP 172–86. The Effect of Cathodic Treatment on the Anodic Polarization of Copper Sulfides, by J. E. Gebhardt, J. J. McCarron, P. E. Richardson, and A. N. Buckley. Hydrometall., v. 17, No. 1, Nov. 1986, pp. 27–38. Studies on the cathodic polarization behavior of copper sulfide electrodes have been conducted by the Bureau of Mines as part of an investigation of the simultaneous production of soluble copper at mineral anodes and soluble sulfur species at mineral cathodes by electrolysis in membrane cells. The application of a cathodic current to anodically polarized copper sulfide electrodes was used to reduce the surface product layer to either chalcocite or elemental copper. The effect of cathodic treatment was to allow additional anodic current application at low potential values. Low potentials would greatly improve the economics of a process based on these concepts. Rest potential and X-ray photoelectron spectroscopic data were used to help identify the surface product layers formed by anodic and cathodic treatment. A cyclic anodic-cathodic technique to achieve dissolution of copper sulfide minerals is suggested.

OP 173–86. Kinetics and Equilibria of the Pd-Cl System, by Arne Landsberg. J. Less-Common Met., v. 123, 1986, pp. 175–183. This study is a continuation of an attempt to characterize the interactions of chlorine and pure metals and to provide data that can be used when considering the compatibility of chlorine and other materials. Anomalies in the interactions of gold and of platinum with chlorine in an investigation of metal corrosion by chlorine, and the kinetics and equilibria of the similar Au-Cl and Pt-Cl systems were previously examined in detail in two papers from the Albany Research Center of the Bureau of Mines. This paper presents data and their interpretation demonstrating similarities between these systems and the interactions between palladium and chlorine.

OP 174–86. A Novel Technique for Dewatering Waste Slurries Containing Clay Particles, by B. J. Scheiner, A. G. Smelley, and D. A. Stanley. Paper in Flocculation Sedimentation and Consolidation, ed. by B. M. Moudgil and P. Somasundaran (Proc. of Engineering Foundation Conference, Sea Island, GA, Jan 27–Feb. 1, 1986). Eng. Found., 1985, pp. 549–564. The Bureau of Mines investigated a technique for dewatering clay waste consisting of flocculation with polyethylene oxide followed by screening of the resulting flocs. Results of laboratory tests as well as the results of small-scale and large-scale field tests are described in this paper. The procedure has been applied to clay wastes from phosphate, coal, bentonite, and potash operations and to the tailings from uranium, talc, copper, gold, silica, and mica mining operations.

OP 175–86. Musculoskeletal Injuries in Underground Mining, by Terrance J. Stobbe, Thomas G. Bobick, and Ralph W. Plummer. Paper in Proceedings of the International Conference on the Health of Miners, Pittsburgh, PA, June 2–7, 1985, ed. by Robert W. Wheeler. Am. Conf. Gov. Ind. Hyg., Cincinnati, OH, v. 14, 1986, pp. 71–76. Job-related musculoskeletal injuries are a continuing problem in all of industry. Mining is no exception. This paper presents an overview of the problem by summarizing strain and sprain injury data for underground mining. The data sources include both MSHA's accident statistics and individual company injury records.

OP 176–86. Application of FT-IR Spectroscopy for In Situ Studies of Sphalerite With Aqueous Solutions of Potassium Ethylxanthate and With Diethyldixanthogen, by S. C. Termes and P. E. Richardson. Int. J. Miner. Process., v. 18, 1986, pp. 167–178. This paper describes Fourier transform infrared spectroscopy used by the Bureau of Mines to study, in situ, the reaction of aqueous solutions of potassium ethylxanthate (KEtX) with copper-activated sphalerite. The use of a transmittance technique is possible for sphalerite because, besides being the reactive mineral surface, sphalerite is also an infrared-transparent material in the region where some of the characteristic vibrational bands of xanthates occur. Bands characteristic of copper(I) ethylxanthate were evident after 5 min of reaction between aqueous KEtX solutions and activated plates. The bands continued to grow as the reaction proceeded and were also present on dried surfaces after the reaction. Diethyldixanthogen dissociated on copper-activated surfaces, and bands characteristic of copper(I) ethylxanthate were detected on the surface of dried plates. No evidence for zinc(II) ethylxanthate formation with either unactivated or activated plates was obtained.

OP 177–86. First Impulse Turbine in the U.S. Mining Industry, by Robert Torbin, Robert Cardenas, and Edward Thimons. Paper in Proceedings of Waterpower '85, Las Vegas, NV, Sept. 25–27, 1985, ed. by Michael J. Roluti. Am. Soc. Civ. Eng., New York, NY, 1985, pp. 183–191. This paper describes a Bureau of Mines research project to investigate the improvements made in the operation of mine refrigeration systems when a thermal energy recovery system is incorpo-

rated. The project involved the use of an impulse turbine-generator system that extracts energy from the incoming cooling water. The shaft work performed by the turbine not only produces electricity, but reduces the thermal energy gain of the incoming water. The reduction in thermal gain is equivalent to the shaft work extracted by the turbine. The system has been operating for more than 9 months and has produced more than 800,000 kW·h of power.

V. Patents

These patents, which may be used by any U.S. citizen or organization without royalty payment upon authorization by the U.S. Department of the Interior, were developed by Bureau scientists or under contracts with the Bureau. Application should be made to—

Branch of Patents
Division of General Law
Office of the Solicitor
U.S. Department of the Interior
Washington, DC 20240

U.S. Pat. 4,613,069. Method for Soldering Aluminum and Magnesium. Wilbert L. Falke, Agnes Y. Lee, and Leander A. Neumeier. Sept. 23, 1986.

U.S. Pat. 4,615,874. Process for Producing Chlorine From Ferric Chloride. Richard S. Olsen and Glenn C. Brown. Oct. 7, 1986.

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